CURIOSITIES

OF

PHYSICAL GEOGRAPHY.

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SERIES I

EARTHQUAKES AND VOLCANOES.

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Section I.—Snow-Mountains.

The planet we inhabit is enveloped by air, which follows its motions and revolves with it about its axis. Air must therefore be considered as an integral part of the planet, and our globe to consist of air, land, and water. When air is spoken of as a separate and distinct body, it is called atmosphere. It must not be supposed, however, that the whole space which intervenes between our planet and other celestial bodies is filled by air. If that were the case, we should never have night, but that part of the natural day which we call night would be distinguished from that which we call day only by a fainter light, resembling twilight, for twilight is but the reflection of the sun's light from the higher strata of the atmosphere; consequently, if the whole space extending from our globe to the other heavenly bodies were filled up by air, strata of air would be found over our heads, so situated as to lie beyond the shadow of our earth, and these strata would reflect the sun's light all the time the sun was under the horizon, and would change the darkness of our nights into twilight. As this does not take place, we are compelled to conclude that only the space near our earth is occupied by air, and that at some distance from it air ceases to exist.

This leads us to the question, to what distance from the surface of the earth does the atmosphere extend? We have no means to determine this point but by the duration of twilight. It is, however, very difficult to

ascertain exactly the length of time which twilight lasts. We know exactly the time it begins in the evening, namely at sunset, and also when it terminates in the morning, namely at sunrise, but its termination in the evening, and its beginning in the morning, are difficult to fix, to estimate, as the changes in the light are so extremely gradual that our sight has not that degree of nicety which is required to mark exactly the line which separates night from twilight. Besides, it is a known fact that the length of twilight varies at the same place according to seasons, and also that it varies at different places, when they are situated to the north or south of one another. Taking all these differences into account, it has been roughly calculated that the mean duration of twilight is about half an hour. Now it is known that in that time the sun descends fifteen degrees below the horizon; and taking these two facts as premises, it has been calculated that air which is still able to reflect the sun's light ceases to exist at a distance of about 81,000 yards, or forty-six miles, from the surface of our planet. This is therefore the extent of the atmosphere.

Each of the three substances of which our globe is composed—earth, water, and air—is possessed of some peculiar qualities. One of those by which air is distinguished, is its great elasticity, in virtue of which it may be compressed by external force, but expands again as soon as the pressure ceases. This peculiarity of the air imparts to our atmosphere a peculiar constitution. A certain space, say a cubic foot, contains a greater quantity of air near the surface of the earth than at a distance of a hundred feet from it, and the contents of air in a cubic foot at the latter place are much greater than when taken at a distance of a thousand feet from the surface, and so on. The farther we recede from the surface of the earth, the smaller is the quantity of air contained in a determined space. To this peculiar constitution of the atmosphere the terms *density* and *rarity* are applied. When a greater quantity of air is contained in a certain space, it is said that the air is more dense; and when a smaller quantity is found, it is said

that it is more rare. Frequently the term denser and rarer strata is used to indicate the difference of the quantity of air contained in a determined space at different distances from the surface of the earth; but there are, properly speaking, no strata, the air becoming continually and gradually rarer as we recede from the surface of the earth. It is not difficult to account for this peculiar constitution of the atmosphere. The air is compressed by its own weight—that is to say, the air superincumbent on the surface of the earth has to sustain the pressure of the whole volume of air which lies above it, and extends to the very limits of the atmosphere, and by this weight it is compressed. At a distance of a thousand feet from the surface of the earth, it has to sustain the pressure of a column of air which is by a thousand feet shorter, and contains a more rarefied air. It therefore is compressed by a much lesser weight, and in consequence does not acquire the density which is found in the air contiguous to the surface of the earth. Thus the density of the atmosphere must decrease in proportion as we recede from the surface of the earth.

This peculiar constitution of the atmosphere greatly affects the climate of the habitable portion of the globe. The air in itself is neither warm nor cold, but it is gifted with the quality of becoming heated by the sun's rays. The degree of heat imparted by the sun's rays to the air depends partly on the length of time during which the rays act on it, and partly on the degree of its density. The heat is consequently greater where the air is denser, and less so where the air is rarer. Places which are low (that is to say, which are but little raised above the level of the sea, which is to be considered as the true surface of the globe) are much warmer than places which are some thousand feet above the sea-level. The difference increases in proportion as we ascend higher above the sea. When we thus continue to ascend, we at last come to places where the air is so rare that the degree of heat imparted to it is so small that water no longer continues in its fluid state, but is converted into ice, or, if in the form of vapour, into snow. That stratum

of air where this change takes place in the atmosphere is considered as a line marked by nature itself, and called the *snow-line* As the heat increases or decreases exactly in proportion to the increase or decrease of the density of the air, and as this density decreases regularly in receding from the earth's surface, we should expect that the snow-line would occur at the same distance from the earth's surface at every place in the globe, but this is not the case It occurs at a much greater elevation in the torrid than in the temperate zone, and is still lower in the frigid zone To explain this phenomenon we must call in another law of nature

The density of the air alone does not constitute the temperature of a place It depends as much, if not more, on the manner in which the sun's rays act on the air. The greatest degree of heat is developed where the rays pass perpendicularly through the atmosphere A much smaller degree of heat is produced when the rays fall obliquely, and the greater this obliquity, that is to say, the smaller the angle formed by the sun's rays and the surface of the earth, the less heat is developed in the air Those countries only which are situated between the two tropics are heated by the perpendicular rays of the sun, or are acted upon under a very great angle Therefore a greater degree of heat is developed in the air, and their temperature is much higher. Countries lying without the tropics, but not far from them, are only acted upon by the oblique rays of the sun, and their temperature is lower In proportion as we recede from the tropics towards the poles, the degree of heat decreases more and more until we arrive at the vicinity of the poles, where the angle under which the sun's rays act upon the atmosphere is so small as to develop a degree of heat that would be hardly sensible if the sun did not remain for several months above the horizon.

This arrangement of nature of course greatly affects the elevation of the snow-line. In hot countries it is much farther from the surface of the earth than in temperate countries, and in these farther than in cold countries By numerous observations, it has been ascer-

tained that in those countries which are near the equator the snow-line is found about 16,000 feet, or three miles, above the sea-level. In places which are equally distant from the equator and the poles—namely, in those near 45° of latitude—it occurs at an elevation of 9000 feet, or one mile and three quarters. Under 60° of latitude, snow is always found on mountains which rise to 5000 feet, or to less than a mile, above the sea-level; at 70° of latitude, at an elevation of 1000 feet, and at 80° the snow-line comes down to the surface of the earth, for countries which are 10° of latitude distant from the poles are covered with snow all the year round, even when their level is only a few inches above that of the sea.

Between the snow-line and the surface of the earth is the space which is assigned to nature for its organic operations. It is here that all the plants germinate and grow, that animals find their food, and man what is requisite for his subsistence. Though man finds it too cold to settle permanently near the snow-line, he visits its vicinity during the summer with his herds. Where cattle and sheep do not find pasture, the reindeer and the yak find their favourite food. The last-named animal is little known. It lives in the most elevated part of the globe, the table-land of Pamir, which by the natives is emphatically called 'The Roof of the World.' The yak is of the ox species. It stands about three feet and a half high, and its belly reaches within six inches of the ground. Long hair streams down from its dewlap and fore-legs, and its bushy tail sweeps the ground. Other animals require the provident care of men to subsist them through the winter. The most hardy sheep would fare but badly without human protection, but the yak is entirely left to itself. It frequents the mountain slopes and their level summits. Wherever the mean annual temperature does not rise above the freezing-point is the climate for the yak. If the snow on the elevated flats lie too deep for him to crop the herbage, he rolls himself down the slopes, and eats his way up again. When arrived at the top, he rolls down again, and completes

his meal as he forms another groove of snow in his second ascent The heat of summer sends the animal to the places constantly covered with snow, and the inhabitants leave their sheltered valleys and follow their herds. The milk of the yak is richer than that of the common cow, but the quantity it yields is less Their hair is clipped once a-year in the spring it is strong, wiry, and pliant, and is made into ropes, which for strength do not yield to those manufactured from hemp The hair of the body is woven into mats, and also into a fabric which makes excellent riding trowsers Its bushy tail is the well-known *chowry* of Hindustan, where it sells very dear on account of its great beauty, and where it is used as a fan. If we add the use which is made of its flesh as food, its hide for boots and other articles of dress, and its horns for drinking-vessels, we may say that this animal, which lives on the very border of the snow-line, is able to satisfy, like the reindeer of the Laplanders, nearly all the wants of men It is besides used for riding, and on the mountains which it inhabits is preferred to all other animals for that purpose Wherever a man can walk, a yak may be ridden Like the elephant, he possesses a wonderful knowledge of what will bear his weight If travellers are at fault, one of these animals is driven before them, and it is said that he avoids the hidden depths and chasms with admirable sagacity Should a fall of snow close the mountain passes to man and horse, a score of yaks driven a-head soon tread down the snow, and make a practicable road.

Wherever in the torrid zone a mountain-mass rises to such a height that its top is always covered with snow, a traveller may in ascending its acclivities pass in a short time through all the climates he would encounter in travelling from the equator to the moss-covered mountains of Lapland At and near the base of the mountain his way lies through plantations of palms and plantains, through fields of sugar-cane, cotton, and other tropical productions, and through groves of the most delicious fruits. By degrees the scene changes, and when he has mounted about 8000 feet about the sea-level, he finds

himself surrounded by forests of oak, beech, and other trees of the temperate zone, which are frequently interrupted by fields of wheat, barley, and other productions of our country, interspersed here and there by groves of apple, peach, apricot, fig, and orange trees The trees with deciduous leaves are soon displaced by conifera, such as the pine, fir, larch, &c., the fields present only barley and potatoes, and the fruit-trees have given way to bushes, such as raspberry and others. When the traveller leaves this region and approaches the snow-line to within a thousand feet and more, the bushes and fields disappear entirely, and the stones of the mountains are only clad with herbage, among which here and there single flowers are observable. But near the snow-line itself the whole mountain-mass, where its acclivities are not too steep to admit of vegetation, is overgrown with mosses

The mountains which are always capped with snow, not producing anything useful to man or beast, would seem to be useless in the economy of nature as far as regards the maintenance of the animated creation But such is not the case They diffuse fertility through extensive countries, by giving rise to rivers, and by keeping them well supplied with water, which may be applied by the inhabitants, and at many places is applied, to irrigate the fields and to obtain from them richer crops than could be got by any other mode of management This is especially the case in warm countries, where rains are periodical, and where for several months not a drop of rain falls. During these rainless seasons the soil is dried and parched by a continual evaporation, and all minor vegetation would die away were the waste of moisture not supplied by irrigation with water drawn from the rivers. It is true that mountains which do not rise to the snow-line keep up the water in the streams all the year round, but their supply is but scanty when compared with those rivers whose sources are found under eternal masses of snow. Though on the banks of the first class of rivers a considerable population may subsist on the produce of the fields, it is not commonly half as large as that which owes the supply of its wants

to the bounty dispensed over their fields by the snow-born streams In our countries, which kind Providence has blessed with an annual fall of snow and with abundant showers of rain during all seasons of the year, the advantage which hot countries derive from such rivers can hardly be understood in all their extent, and consequently has not been duly appreciated But what immense tracts of the surface of the globe would be nothing but mere wastes were their rivers deprived of that continual supply of water, which is derived from the gradual but never ceasing melting of the snow with which the summits of their mountains are crowned!

The snow-mountains are rarely visited by travellers, except along those foot-paths which lie across mountain-passes, and serve as the shortest lines of communication between places situated on different declivities at some distance below the snow-line Such persons are hasty pedestrians, and commonly do not pay much attention to the operations of nature But several of those worthy persons, who wish to make themselves acquainted with all the particular phenomena of the works of God, have not hesitated to ascend the highest summits as far as possible, to explore these regions which appear to be the abode of horror and desolation. They have not been diverted from their purpose, or terrified at the dangers which surrounded them among these enormous masses of snow and ice, on the edge of perpendicular precipices, and on the bank of yawning chasms many hundred feet in depth nor have they hastily withdrawn themselves from those unpleasant sensations to which their bodies were subjected by the exceedingly rarefied air which they respired at such a great elevation These sensations are not experienced in the vicinity of the snow-line, but only when the elevation of the mountain is considerably above it. The most remarkable is the feeling of exhaustion. When Lieut Wood was on the Roof of the World in Pamir, he wished to ascertain the depth of the lake Sir-i-kol, and for that purpose tried to make an opening in the ice. He found that the slightest muscular exertion was attended with exhaustion. Half a dozen

strokes with an axe brought the workman to the ground; and though a few minutes' respite sufficed to restore the breath, anything like continued exertion was impossible. A run of fifty yards at full speed made the runner gasp for breath. Indeed this exercise produced a pain in the lungs and a general prostration of strength, which was not got rid of for many hours. The human voice was sensibly affected; conversation, especially if in a loud tone, could not be kept up without exhaustion, and the pulse throbbed at a frightful rate. Saussure, when on Mont Blanc, experienced the same effects, and, besides, he and his party complained of dizziness and head-ache; they lost their appetites, but were tormented by an ardent thirst, which could only be allayed momentarily by cold water A complete indifference respecting all worldly objects pervaded their minds When Humboldt attempted to ascend the Chimborazo, and had nearly attained its summit, he desisted on finding that drops of blood issued from under his nails and from his eye-lids

The greatest number of snow-mountains, as far as is known, are found in the Himalaya Mountains, or those mountain-masses which lie along the north-eastern border of Hindustan, and separate the British dominions from the Chinese empire. Along this line, for a distance of several hundred miles, masses of rocks occur from thirty to forty miles in width, which rise to from 18,000 to 25,000 or 26,000 feet above the sea-level, and from 6000 to 14,000 feet above the snow-line. The depressions by which those masses are divided from each other hardly at any place sink to 15,000 feet above the sea-level, or to 3000 feet above the snow-line. Through these depressions lie the mountain-passes, by which the communication between the two countries extending on their sides is carried on. These passes are only practicable during two or three months of the year, and even then the cold experienced is so great that horses, mules, and other animals of burden cannot endure it Sheep alone are by nature so well protected against the effects of frost that they are not materially affected by the intense cold of this region, and for that reason these weak

animals have been converted into beasts of burden. Rice and a few other articles are conveyed on their backs from the plains of the Ganges to the table-land of Thibet.

The best known snow mountains in Europe are those of the Alps. The number of the rocky masses rising above the snow-line amounts to some hundreds. At a few places they are so closely connected as to constitute a snow-mass covering a great extent of country. In the Alps of Berne, between the upper courses of the rivers Rhone and Aar, an extent of country of about six hundred square miles, or twice the area of the county of Middlesex, is one sheet of snow, with the exception of three or four narrow valleys, which run into the mass, and are so depressed as to be free from snow for several months of the year. The valleys cut in these mountains communicate with one another by foot-paths, which run for several miles over the snow, but are only practicable for a few weeks in the year, and then only for pedestrians. The snow-fields of the Alps hardly ever present level spaces on their tops of any great extent, as the snow is there lodged on declivities, which are frequently broken by short but steep ascents and descents This imparts to their scenery a certain variety, which is greatly enhanced, and converted into a most majestic and impressive view, by the great number of rocky masses with which, in the forms of needles, steeples, ruined castles, and narrow ridges, their surface is overspread. As these rocks in most cases rise perpendicularly, or nearly so, their sides are too steep to permit snow to lodge on them, and their black colour contrasts in a most striking manner with the whiteness of the snow Thus these snow-fields constitute one of the most attractive beauties in the scenery of the Alps.

But all snow-mountains do not present such scenery. There are in other countries extensive plains of nearly a level surface, which are raised above the snow line, and consequently always buried under snow Such plains are found in Norway. Though these snow-plains are destitute of that majestic beauty which imparts to the

snow-mountains such a degree of attraction, they are still interesting, as they show us the true nature of snow mountains, without the association of those impressions which are the effect of accidental circumstances. The best known of the snow-plains of Norway is that of Folge Fonden. It is not quite destitute of occasional beauties, but those are only found along its edges, which are surrounded on three sides by firths, or deep and narrow inlets of the sea, affording a great variety of views on the steep acclivity of the mountain-mass, over whose upper surface the snow-plain extends Folge Fonden is a peninsula, which in its greatest length, from south by west to north by east, extends more than thirty miles, and in its width varies between twenty and eight miles On the south-east it is connected with the mainland. The rocky masses of which this tract is composed rise on all sides with a steep acclivity to an elevation of more than 5000 feet, and their upper surface is a level plain covered with snow When seen from below, it appears that the snow-mass is about twelve yards deep That which lies uppermost, and which is the produce of the snow-falls of the last winter, is quite white, and forms a well-marked thin stratum, whilst the remainder appears to constitute one compact mass, whose white colour is slightly tinged with blue Near the edges of the snow its surface is gently inclined, rising gradually towards the centre, and only at a few places, where the edge is broken by ravines, is the declivity more rapid The inclination of the surface decreases in proportion as we advance towards the interior, and near the centre it frequently presents a dead level, across which a few low eminences extend in the form of large waves with a very gentle ascent. The snow itself appears as a conglomerate of small transparent grains of ice, resembling in form and size very minute shot, which probably at some distance under the surface are united into one mass of ice by the pressure of the superincumbent snow-masses. The surface of the snow is quite smooth, and when visited in summer, after the sun's rays have made a faint impression, by dissolving the outside of the grains to a

small degree, it is covered by a very thin layer of ice, as if it had been glazed, whilst on the inclined portion some slight furrows are observed which have been formed by the small quantity of water produced by slight thaws. When a stick is pushed into the snow, the resistance which is experienced continues to increase, so that at a small depth it becomes impossible to force the stick farther down.

What a different scene is presented by the snow fields of the Alps! These are the produce of enormous snow masses, which have accumulated on steep and irregular slopes The continuity of their surfaces is broken at numerous places, and there the snow-masses, resembling ice in texture, rise like walls, crowned here and there by boldly ascending pyramids, or by groups resembling broken down buildings of ancient date This majestic confusion receives a peculiar charm from the bluish colour, with which the ruptures of the icy masses are tinged. At many places the masses are furrowed by clefts several feet wide, which descend to a depth of a hundred feet and more. These clefts are numerous, where the snow masses, in descending over a very steep slope, or into a deep ravine, have been fractured by their own weight, and they are still more numerous where an unwieldy mass, hemmed in between two mountains, in protruding downward to form a glacier has not found a space large enough to preserve its width, and thus has been broken along its edges by the resistance offered by the rocks on its sides, or by the rapid declivity of the valley into which it descends.

The snow of these high regions consists, as already stated, of small round balls, resembling in size and form small shot of a diminutive kind This at once shows that this snow is very different from that of the lower countries, where the snow falls in flakes This difference is also proved by the fact, that it is impossible to press it together so as to make a snow-ball. The German peasants in Switzerland have well observed this difference, and express it in their language, calling the mountain snow *firn*, in contradistinction to *snow* As no snow-

ball can be made of this kind of snow, it is evident that none of the snow avalanches can originate on the snow-fields, though that opinion has been maintained up to very recent times. At and near the surface of the snow-fields the snow particles are disunited, and do not adhere to one another, but at some depth it is found that they change in some degree their form, becoming more flattened. In this form they approach closer to one another, and being pressed by the superincumbent stratum, they by degrees unite into one mass, which has a resemblance to the ice of which the glaciers are composed. When the mountain-mass on which the snow rests is not much raised above the snow-line, this change in its form begins to take place at a depth of a few feet below the surface, but where the mountains rise to twelve thousand feet, or four thousand feet above that line, the snow preserves its granular form to a great depth, so that only the lower stratum assumes the appearance of ice

The difference between the snow of the lower countries and that of these elevated regions shows that they must be formed under different circumstances. It is easy to comprehend that only a small mass of aqueous vapour can ascend into the rarefied air which rises above the summits of the snow-mountains Rain of course does not fall, as all vapours rising to that elevation are converted into snow The summits of the mountains are, besides, above the region in which rain is generated. Heavy rain-clouds are only seen to hover over those declivities of the mountains which are overgrown with large trees The region of the forests extends in the Alps from 3000 to 6000 feet above the sea-level, and in this region rain in summer and snow in winter are very abundant Where the trees disappear, and are replaced by bushes, the quantity of rain decreases gradually, and goes on decreasing in approaching the snow-line Above this line only snow falls, not in the form of flakes, but in that of very minute globules. The quantity of snow which falls in spring and autumn is not great, in winter it is still smaller, and in summer snow does not fall at all. It appears, therefore, that the whole annual quantity of

snow in that elevated region is but small, which is a wise arrangement of Providence, as otherwise the snow would accumulate to an immense extent, and to such a height, that it would be impossible to pass the mountains. For these masses do not experience any diminution, except by evaporation, and it is evident that in such a rarefied air, and in such a cold climate, evaporation cannot but be very small.

Section II.—Glaciers.

The term glacier is frequently considered as being synonimous with that of snow-mountain, and both terms are sometimes used without discrimination, but they indicate very different objects, as the reader will convince himself by comparing the following account of the glaciers with the preceding one of the snow-mountains.

Glaciers are appendages to snow-mountains. There is no glacier and there can be no glacier without a snow-mountain The glaciers are offsets of the snow-mountains. They may be compared with the branches of a tree, which extend to a considerable distance from the trunk The snow-line itself constitutes the point where the snow-mountain terminates and the glacier begins. An extensive snow-mountain may send off a great number of glaciers. The number of glaciers which emanate from the snow-fields covering Mont Blanc amount to seventeen or eighteen, and the number is still greater of those which originate in the immense snow-masses which divide the upper course of the river Rhone from that of the Aar.

If we suppose that a mountain, whose summit is crowned by an extensive and deep mass of snow, descends on all sides with a gentle slope, we should find that the outer edge of the snow was girded by a broad band of ice all round. The cold emanating from the snow would chill the adjacent air to a certain distance from the edges of the mass, and so far the ice would extend. As this border lies below the snow-line, the alternation of cold and warmth to which it is exposed would convert the snow into ice of such a description as

is found in the glaciers We might, therefore, expect to find that all the edges of snow-mountains are surrounded by glaciers, and so they are in reality, but the greater number of them are so small as not to excite observation. The extent of a glacier depends almost entirely on the conformation of the declivities of the mountain on which the snowy mass rests When such a mountain descends with a perpendicular or very steep declivity to a considerable depth below the snow-line, its edges terminate so abruptly as to leave no space for the formation of a glacier, except perhaps a very narrow border, which can hardly be distinguished from the snow which lies higher up An instance of this kind is seen in the Folge Fonden, in Norway Along its northern and western edges only a few depressions occur, in which glaciers of several hundred yards in extent are to be met with, and at the termination of which the mountain-mass descends with great steepness On all its other sides no traces of glaciers are found. Such a formation of the mountain-masses, though frequent in many countries, rarely occurs in the Alps The snow-covered portion of this mountain-system is on all sides surrounded by other ridges, which are connected with it at different angles, and between which valleys of various extent are found. The smallest glaciers occur on the sides of the snow-mountains themselves Wherever there is a ravine which begins under or on the very edge of the snow, and thence descends, a glacier is formed But as these ravines have a very rapid descent, the glacier terminates at a short distance from the snow-mass, where the slope of the ravine becomes too great to afford a permanent lodgment for the snow which is borne down by its own weight At other places the ravines terminate at their lower extremity in a level tract covered with grass, on which the descending snow is soon melted away There are also a few instances where the declivity along the sides of the mountain for a considerable extent is so regular, moderate, and uniform, that the snow for some distance from the edge of the perpetual

snow finds support on the slightly inclined plane, and where therefore a glacier of several hundred feet in width borders the snow-masses from which it has descended. The small extent of all the glaciers of these kinds, and their remoteness from inhabited places, would hardly have excited attention, and given rise to an investigation of their peculiar nature. But there are glaciers of great extent. They are sometimes twenty miles long, and descend so far below the snow-line, that their termination is surrounded by full grown trees, cultivated fields, and orchards. These glaciers are only to be met with in valleys which descend with a gentle slope to a great distance from the snow-mountain, and are enclosed on either side by a secondary ridge of considerable elevation, which is connected with the snow-mountain at the beginning of the glacier.

The extent of a large glacier depends partly on the size and formation of the valley, and partly on the extent of the snow-mountain of which it is a branch. The peasants in Switzerland say, a lean snow-mountain cannot produce a fat glacier. A snow-field must be indeed very large to be able to supply annually a quantity of snow sufficient to feed a glacier, which descends several hundred feet below the snow-line, and is there exposed to a great waste from evaporation and melting. On this account alone a great difference in the extent of glaciers may be expected. The glacier in Switzerland which descends to the lowest level is the famous one of the Lower Grindelwald, which is annually visited by crowds of travellers, because it descends so far, and is consequently more accessible than others. The lower extremity of this glacier is only 3409 feet above the sea-level, though the lower edge of the snow-mountain from which it emanates is 8117 feet above that line. Its neighbour, the glacier of the Upper Grindelwald, terminates at an elevation of 4260 feet, and the Great Aletsh glacier, which opens into Valais, at 4413 feet above the sea. The other glaciers which are found in the Alps do not extend so far down, but in other countries some are found which approach much nearer the level of the sea

On the western coast of Norway, near 66° lat., is Cape Kunnen. It is partly formed by a glacier which descends quite to the water's edge, except towards the end of the summer, when it recedes a few feet. Henderson, in his travels through Iceland, makes mention of the Bridemarker Yokul, a glacier in the eastern districts of the island, which had advanced so near the sea that there was hardly space enough left for a road, and it was feared that the glacier would extend itself to the water's edge, and close up the communication between the eastern and western parts of the island. The eastern shores of Greenland are so lined with glaciers that a great portion of the cliffs which front the sea are entirely composed of ice, and rise some hundred feet above the sea. Similar cliffs of ice occur in some of the inlets with which the western coast of Patagonia is indented. It is evident that in all these countries enormous masses of snow must cover the higher parts of the mountains, when we find that these offsets extend even to the shores of the sea.

The Alps of Switzerland are famous for the number and extent of their glaciers. The declivities of all those parts which sustain large masses of ice are, as it were, striated by comparatively narrow masses of ice, which descend to the valleys between the secondary ridges like rivers between their banks. In arriving at the lower extremity of a glacier, it is found that the icy mass rises with a broken and steep ascent to a considerable elevation. The masses which lie behind this projecting promontory are also much broken, traversed in every direction by deep chasms, and overtopped by numerous isolated pieces of ice, which exhibit the most fantastic shapes. In advancing farther the glacier resembles a gently sloping icy stream from half a mile to three miles wide, presenting a surface more or less undulating, and this undulating surface is more or less broken by chasms, which at their upper opening differ in width from a few inches to many feet. These chasms sometimes extend nearly from one side of the glacier to the other. The ice of the lower part of the glacier is, in general, tinged with an exquisite blue colour, which, however, in many parts passes into a

green. Near the snow-mountain the blue colour becomes fainter, until it disappears entirely. In those parts where the glacier approaches the snow-masses its surface is again more broken than in its middle portion. Along the sides of the glacier are icy walls, sometimes sixty feet high and more, on which masses of bare rocks of different size are lodged. Such walls also usually surround the lower extremity of the glacier, and frequently are found in its middle. They are called *moraines.* Sometimes large pieces of rock, supported by a column of ice, are found on the surface of the glacier They are called *glacier-tables*

In examining more closely the phenomena of the glaciers, the *ice* of which they are composed first claims our attention It differs as much from that which is formed in our rivers and lakes as the snow of the snow-mountains differs from that which falls in lower regions Whoever has paid attention to the formation of ice in a pond, or along the banks of a river, must have observed that at first crystals having the form of long and thin needles make their appearance, but after they have united into a sheet of ice no marks of crystallization are apparent The ice of the glaciers is composed of crystals, but their form differs greatly from those which are observed at the first formation of ice in water. They are polyhedrons of the most irregular shapes, but more oblong than entire. Their size varies from less than an inch to three inches in length. They have commonly on one side, rarely on both, a small protuberance, which, however, has no determinate shape, and varies greatly in form. The surfaces of the crystals are rough, warty, and slightly furrowed The manner in which these crystals are united into one mass is very remarkable By the pressure they have undergone they are wedged together, and by means of the protuberances are so fixed into each other, that when exposed to a temperature capable of dissolving the whole mass, the single crystals become moveable to a certain extent, but they do not fall asunder even if the interstices have already loosened. When in this state it is still found a somewhat difficult matter to take

out a single crystal, and for that purpose a force must be employed by which the crystal is generally broken. As soon, however, as one crystal is removed, the others may easily be detached, and the whole mass taken to pieces. Sometimes even, by the removal of a few crystals, the whole mass will directly fall asunder. It happens, sometimes, that large pieces of ice detach themselves from the lower extremity of a glacier, or from its outer border. These masses do not melt like common ice exposed to a high temperature, by diminishing continually The mass keeps its size and form until the whole has been completely moistened, and the single crystals have become loosened, and then the whole mass at once falls to pieces This singular composition gives to the whole icy mass a cellular texture, which may be distinctly observed on the surfaces of the vaults which invariably occur at the lower termination of the glacier Neither in the interior of the mass nor on its upper surface does this cellular texture show itself—at least not distinctly, when the temperature is low, or after a cold night But it becomes apparent if coloured acids or spirits are diffused on the mass These fluids penetrate deeply into the ice by means of the interstices, and both the crystals and interstices may be distinctly traced It is further remarkable that these crystals attain their greatest size at the lower extremity of the glacier, and that their size is in proportion to the mass The larger the mass, the larger the crystals At the lower extremity of the glacier the crystals are of equal size, or nearly so, throughout, but on examining them farther upwards, and nearer the snow-mountain, they are found to be smaller on the surface of the glacier than in the interior, and that they increase in size in proportion to the depth. On the summit of the snow-mountain itself, when the upper stratum, which consists of snow, is removed, it is found that the mass below it presents the cellular texture of the glacier, but the single crystals are of smaller size

The surface of the ice itself is extremely uneven and rough, bearing no resemblance to the ice of our ponds and lakes, which admits of skating This roughness is to be ascribed to the different degrees of hardness of the

ice itself, and to its peculiar structure. The whole mass is composed of two kinds of ice, different in hardness and in colour They are disposed in bands or parallel veins. Thin plates of compact transparent ice alternate with others which are less hard and semi-opaque. The former are smooth, and contain nothing but ice; but the semi-opaque plates are full of air-bubbles of various forms, which are disseminated through the pure ice, and always arranged in more or less abundance in parallel planes. This imparts to them a frothy and semi-opaque appearance The colour of the compact ice is blue, but that of the opaque a greenish white The harder ice is less easily thawed than the opaque ice, and therefore the surface of the latter is more depressed under the general level than that of the former which thus forms projecting ridges, separated from each other by grooves, and where this disposition of the ice continues for many fathoms, the grooves resemble the cart-ruts of a bad road.

The upper surface of the ice is distinguished by its great dryness. This has been considered as a proof that the diminution of the mass on its surface is produced by evaporation, and not by thawing It is indeed stated that the sun's rays, even in hot weather, hardly affect the ice of the glaciers, and in proof of this supposition the fact is adduced that but rarely even small collections of water are met with Wherever there appear small rills of running water, their origin may be traced to the sudden melting of recently fallen snow But this phenomenon may be accounted for in a more satisfactory way. The interstices between the single crystals have a great capacity of absorbing water, and the slow effects of the sun's rays leave them time sufficient to abstract all the water thus generated on the surface of the glacier

But whilst the upper surface is distinguished by great dryness, the lower, which rests on the rocky bottom of the valley, is extremely wet It is here apparently that the greatest portion of the ice is destroyed by melting. This process is the effect of the natural warmth of the earth, and does not cease even in winter Everybody must be convinced of it who examines with attention the

lower extremity of a glacier. It consists of large caverns or vaults sustained by massive columns of ice These grottos are sometimes a hundred feet high, and from fifty to eighty feet wide, but their dimensions and shapes vary greatly Their sides, acted on by the thawing, are smooth, so that on them the reticular texture of the glacier-ice can be seen with the greatest distinctness Through these apertures all the water is discharged which is collected by the melting of the lower surface of the glacier In winter the stream issuing from them is but small, but in summer it gushes out in a plenteous torrent These streams of the glaciers are remarkable for the whitish-blue colour of their waters, which they preserve for a distance of several miles This colour is ascribed to the numerous particles of rocky matter which the torrents bring down in a state of the greatest comminution effected by attrition.

The surface of the glacier is not continuous and level, but more or less broken The most level part is that in the middle, where, as we have already observed, the surface appears as a gently sloping plain, traversed by a smaller or greater number of chasms, according to the season of the year Near the termination of the glacier, as also at its commencement, the whole mass appears to have been fractured This is easily to be accounted for, as in these parts the bottom of the valley, in which the glacier lies, usually forms a rapid slope, and at the same time uneven and rugged Where the icy masses descend a steep declivity, or are propelled over very broken ground, their surfaces present nothing but a continual succession of irregular and frequently deep chasms, and cliffs of ice rising from twenty to a hundred feet Where the slope of the valley exceeds thirty or forty degrees, the beds of ice break into fragments, which get displaced, upheaved, and piled together in every fantastic variety of form. Masses of ice, resembling steeples or towers, and others having the form of walls, rise with sharp points or edges to a hundred feet, representing an immense ruin converted into ice. But these icy masses are subject to continual changes. "Every moment in sum-

mer," says a modern traveller, "such steeples, walls, or columns break down partly or entirely, and when these icy masses are standing on the edge of a perpendicular or precipitous rock, they tumble down with a loud but peculiar noise, and in falling are broken up into many thousand pieces, which when viewed from afar resemble the cataract of a torrent. This is one of the most extraordinary and grandest views the traveller can enjoy in the Alps."

Chasms have been frequently mentioned There are two kinds of them, which probably owe their origin to different causes, and are distinguished by the names of *day-chasms* and *night-chasms*—because the first are stated to be formed only in day-time, and the last only in the night. The day-chasms may be best observed in the middle and more level portion of the glacier They frequently stretch nearly across the whole width of the glacier, from one side to the other In width they vary from a few inches to many feet at the upper opening. there they are widest, as in descending farther downward their sides contract, until they meet at the bottom in the form of a wedge Some of the wider ones descend to the very base of the glacier An eye-witness and attentive observer gives the following account of the formation of a chasm —"When I was once walking," says Hugi, "on the Glacier of the Lower Aar at three o'clock in the afternoon, and the weather being very [illegible] I heard a peculiar noise. Advancing directly towards the spot whence it proceeded, I had hardly walked thirty or forty paces before I felt that the whole icy mass trembled under my feet. The trembling soon ceased, and then began again, continuing by starts. I quickly discovered the cause The ice was splitting and forming a chasm. Before my eyes it split suddenly over a space of twenty or thirty feet in length, so rapidly that I could not keep up with it Then it appeared to cease, or rather the rent proceeded more slowly, until the trembling returned, and the splitting proceeded at an accelerated rate Several times I advanced to the end of the new formed rent, and laid myself down on the ice. The

chasm opened under my very nose, and I experienced a considerable shock. In this way I followed the splitting of the ice for nearly a quarter of an hour, until it terminated on arriving at a *moraine* When the chasm was forming, its opening was about an inch and a half wide. Afterwards it contracted somewhat, so that at no place was it wider than an inch The depth I estimated at about four or five feet I observed, at the same time, that the splitting downward still continued, but very slowly After some days I again visited the place. I found that the opening had increased to the breadth of six inches, but did not succeed in ascertaining the depth At a distance of about twelve feet another rent had been formed, which extended exactly parallel to the first, and was about six feet deep" These rents are only formed during hot weather, especially when the wind blows from the south-west, and rain is going to fall With the progress of the warm season their number increases, and at its termination the face of the glacier is so changed, that it cannot be recognised by those who had seen it a few weeks before The greatest changes occur in September It is said that during the night the openings contract and grow narrower, and it is further stated, as a well-ascertained fact, that in winter these chasms close entirely, which is ascribed to the expansion and increase of the crystals of ice composing the mass, by the intense cold to which these regions are subject These chasms are considered to owe their origin to the changes of temperature produced by the succession of day and night, of summer and winter This is probable, but we have not met with any description of the process by which they are formed that could carry conviction to our mind.

We are even less acquainted with the nature of the night-chasms These do not frequently occur in the middle portion of the glacier, but are mostly found on its upper extremity, and on the adjacent part of the snow-mountain itself. Their form is the reverse of that of the day-chasms. They have the wider opening directed towards the base of the glacier, and terminates at upper face, under the layer of snow which there co-

vers the icy mass. This layer of snow falls sometimes into the chasm, but more frequently it is carried away by strong gusts of wind, which come up from the interior, and bring up an exceedingly cold air. The interior of the chasm then becomes visible, and it is found that these spacious caverns of wide dimensions are filled with piles of detached ice-blocks, tossed in chaotic heaps, whilst watery stalactitic icicles of ten or twenty feet in length hang from the roof, and give to these singular vaults all the grotesque varieties of outline which are so much admired in calcareous caverns, but which here show to a far greater advantage, in consequence of their exquisite transparency and lustre, and from being illuminated, not by a few candles, but by the magical light of a tender green which issues from the walls of the crystal chambers (Forbes) The herdsmen of the Alps, who in summer frequent the tracts adjacent to the snow-mountains, frequently hear at night an indistinct noise of a peculiar description, which appears to proceed from beneath the glacier It is thought that this noise accompanies the formation of a night-chasm Chasms of this description must be much more dangerous than day-chasms, as their upper opening is frequently covered with snow, and hardly ever perceptible. Many hunters of the chamois have been precipitated to their bottom. No explanation of the origin of these night-chasms has been offered

A phenomenon which has much attracted the attention of scientific travellers are the *moraines*, which term may be translated by *glacier-walls* they are walls of ice extending along the lateral margins of the glaciers, and usually surrounding also their lower terminations. Thus they surround the glacier on all sides, except where it is connected with the snowy masses from which it branches off On the top of these walls are fragments of rock of different dimensions, and stony rubbish, which have there accumulated so as to cover the upper part entirely, and to form long dykes In some of the larger glaciers such a glacier-wall is found in the middle of the icy

mass, where it runs parallel to the walls lying along its borders. It is remarkable that near the upper extremity of the glacier these walls are hardly raised above its general surface, but that in proceeding farther down they rise higher and higher some of them attain an elevation of sixty or eighty feet above their base In approaching, however, the lower extremity of the glacier, they sink gradually down, so that at the termination they are nearly on a level with the surface At some places are found the *glacier-tables* they consist of columns of ice, rising at times to eighty feet and more, and supporting on their tops a large piece of rock, which projects on all sides over the icy column

It is not difficult to account for the rocky masses with which these walls and tables are covered On the snow-fields, from which the glaciers emanate, are numerous masses of rock, which in many places are quite bare of snow, in consequence of the rapidity of their slope. These masses are subject to disintegration by the alternate action of wet and frost, heat and cold It is, therefore, easy to comprehend that, by this disintegration, large fragments of rock are frequently detached, and fall on the ice-field, where they sink into the snow until they meet the compact ice There they remain buried until they are protruded downward to the glacier, when they appear above the surface as soon as the snow melts in the lower temperature. These rocky masses are still increased by the debris which falls from the lateral mountain ridges, by which the glacier is enclosed on both sides These facts account well for the formation of the lateral moraines, but do not apply to those which occur in the middle of the glacier It has, however, been observed lately that the medial moraines are only found in places where two smaller glaciers have united, in the same manner as two tributary rivers form a larger river. At the place of their union the glacier-walls—which skirted the two banks of the glacier which were nearest to one another before their confluence—unite into one moraine, which continues to descend in the middle of the

larger glacier formed by their union. That these medial glacier-walls continue to extend in the middle of the larger glacier to a great distance below the point of union, may be adduced as one of the most convincing proofs that the whole mass of the glacier is continually advancing downward

It is, however, not so easy to assign a reason, why these rocks and *débris* rest on a wall of ice, which, as observed before, is raised at many places sixty or eighty feet above the level of the glacier. Many scientific travellers have exercised their ingenuity in giving an explanation of this phenomenon. They have considered it, with reason, a matter of surprise, that a dead insect or a fallen leaf, soon after it has fallen on the glacier, is buried under the ice, whilst large and heavy rocks, even when warmed by the sun's heat, do not sink under its surface, on the contrary are raised above it, and to such a considerable elevation. The most probable explication is the following The upper surface of the glacier loses, partly by thawing and partly by evaporation, a considerable portion of its ice, and sinks continually to a lower level Where, however, the access of air and light is excluded from its surface by inorganic and compact bodies, the mass cannot be affected by the above-mentioned causes. In this manner the ice on which the fragments of rock are lodged remains undiminished, whilst the adjacent parts sink lower and lower The correctness of this explanation is supported by the peculiar form of the glacier-tables, where the rocky mass on the top projects on all sides to a considerable distance, and the column of ice which supports it grows thinner and thinner the higher the table rises above the glacier, until the column is broken down by the weight of the superincumbent rock, and precipitates it on to the surface of the ice, where, however, it is soon raised again by the effects of thawing and evaporation. The circumstance that organic bodies sink into the ice and disappear in a short time, is accounted for by the well-known quality of such bodies absorbing oxygen. They thus abstract from the ice one of those elements which are essen-

tial to its existence, and the other, the hydrogen, is dispersed by evaporation.*

Almost all travellers who have been in the Alps and have visited the glaciers, speak with rapture of their *colour*. When, however, single crystals, or even small portions of the mass, are broken off, and viewed separately, they show nothing of this colour. They are commonly white and transparent like ice, or frothy and semi-opaque. The colour appears only in the entire mass. The blue colour begins to appear gradually, and passes through all the shades from the slightest tinge to the darkest hue of the *lapis lazuli*. In some glaciers the blue has a mixture of green, which doubtless is to be ascribed to the prevalence of the frothy semi-opaque layers. In the lower parts of the chasms and clefts, where the ice of the glacier is in a state of dissolution by thawing, the blue colour is of a purity and beauty which can be admired, but not described nor imitated. Where the glacier approaches the snow-mountain the colour gets fainter, and at last passes

* In many countries of Europe, as also in England, a number of single pieces of rock are dispersed over some tracts of the country, without its being possible to trace their origin to a mountain, except to such as are very distant—sometimes several hundred miles off. Such isolated pieces of rock are called *erratic* blocks, or *boulders*. Several attempts have been made to explain the manner in which these boulders have been carried to such a distance from those rocks, of which, at some remote period, they apparently constituted a portion. Lately it has been observed, that such boulders, consisting of granite, are dispersed over the declivities of the limestone rocks of the Jura Mountains, and that they are there disposed exactly as if they were brought to these places and deposited by glaciers in the form of glacier-walls. As these boulders on the Jura Mountains are found much below the level to which at present any glacier descends, Agassiz, a Swiss Frenchman, has conceived a theory, according to which by far the greatest part of Switzerland, at some remote period, was covered entirely with snow-masses, which, when the temperature of our globe increased, were gradually melted, and in retreating to the more elevated portion of the country, deposited these boulders at different levels on the slopes of the Jura range.

into that of the ice of the snow-mountain, which, as above observed, is white, with a tinge of blue which is hardly perceptible.

A natural phenomenon of such a peculiar character and such a magnitude as the glacier, has powerfully attracted the attention of scientific men, and several theories have been formed to explain their origin. When the phenomena attending them had been observed, but not closely investigated, an apparently simple method was adopted to explain their origin. It was thought to be due to the quantity of snow which falls in the higher and colder regions of the mountains, and is only partially thawed by the heat of summer. When the slopes of these elevated mountain-masses are rapid, the snow, being unable to rest upon it, slides down into the adjacent valleys in the form of avalanches, and to this being added what in winter-time falls directly into the valleys, an enormous quantity of snow is accumulated, which becomes compressed by its own weight. This snow is converted into ice by the rains which occasionally fall, and by the water, which results from the partial melting of the snow, percolating through the whole mass, moistening it throughout, and while in this state the cold of the succeeding winter consolidates it into a glacier. This explanation, simple as it is, cannot be admitted as founded in truth, when it is considered that but little snow falls on the snow-mountains, that no avalanches originate in these higher regions, and that few of the steeper slopes are so situated as to discharge their snowy coverings into the valleys, the greater number of them being near the crest of the whole mountain-mass. This theory, besides, does not agree with the peculiar nature of the ice, as above described, which cannot have been produced by such a process, nor with the progress which the icy mass is continually making downward.

Saussure, a native of Geneva, the first to investigate closely the glaciers and the phenomena attending them, and to apply to them the known laws of nature, was aware of this progress, and was convinced that the ice of the glaciers originated on the snow-mountain itself, from which it descended slowly to its termination.

Though the fact of this movement was for a long time considered as certain, no attempts were made at any place to ascertain its rate, until Mr. Forbes, Professor of Natural Philosophy at Edinburgh, turned his attention to the subject. By him and his friends the movement of the ice of the littoral part of the *Mer de Glace* at Montlavert, near Chamouny, was attentively observed for nearly a year, and it was found that it amounted

From June 29th to Sept 28th		to 132 feet.
„ Oct. 10th to Dec 12th	.	70
„ Dec. 12th to Feb 17th	.	76
„ Feb 17th to April 4th	.	66
„ April 4th to June 8th .	.	88
		432 feet
To this Mr Forbes adds for the time in which no observations were taken	.	51
		481 feet.

Thus it has been ascertained that at one point at least the annual progress of the glacier-ice amounts to nearly five hundred feet

On this progress of the ice Saussure rested his theory of the origin of the glaciers He maintained, that when by the natural warmth of the earth the connexion between the lower surface of the glacier and the bottom of the valley had been removed, and the ice had become slippery by the moisture collected, the whole mass was borne down by its own weight, and that thus the progress of the glacier-ice was effected by a mechanical operation To this theory it is with reason objected, that by far the larger part of the glacier rests on a slope which is not rapid enough to allow us to suppose that such heavy and enormous masses of ice could be so carried down. Besides, the glaciers do not lie in a straight line, but follow the bends of the valleys They frequently pass through gorges, or round projecting masses. At all such places, the ice, descending of course in a straight line, would be stopped, broken, and accumulate

to an immense extent, which is not the case. On these accounts the theory of Saussure has been rejected.

In later times Charpentier and Agassiz have broached another theory They conceive that the progress of the glacier may be considered as the effect of the freezing of the water which collects in the chasms, clefts, and smaller rents. According to their opinion, a glacier is composed of a spongy ice, which continually absorbs the water derived from the atmosphere and from the melting of the ice itself. This water penetrates into the numerous narrow rents which traverse the icy body to its lowest depth, but especially those parts of it which are contiguous to its upper surface. When this water freezes, it presses with great force on all the parts which surround it, and propels those which lie on that side where the resistance is smallest, namely, down the slope of the valley The weight of the mass assists greatly this movement In winter, when the whole mass is frozen throughout, the glacier-ice does not move. This theory is more ingenious than solid. It appears to be quite impossible, according to all experiments and observations, that the comparatively small quantity of water collected in the rents and lower portions of the chasms, when converted into ice, should act with such a force on its sides as to be able to put in motion masses of such a magnitude as those of the glaciers. Besides, it is not true that the ice of the glacier does not move in winter According to the measurement taken by Professor Forbes, noticed above, it is evident that it moves nearly as quick in winter as in summer

Professor Forbes has conceived a new theory He considers a glacier as not consisting of a mass of solid ice, but as a compound of ice and water, more or less yielding according to its state of wetness or infiltration It is an imperfect fluid, or a viscous body, which is urged down the slopes of a certain inclination by the mutual pressure of its parts, and he compares it to a thick mortar, or the contents of a tar-barrel poured into a sloping channel. Whoever has looked at the manner

in which such a fluid moves, will have observed that the middle part of the moving body advances more rapidly than those portions which form its outer edges, which must overcome the friction caused by contact with the channel, and which therefore are retarded and cannot proceed with equal velocity Evident signs of this kind of movement have been discovered in the glaciers by Professor Forbes. They consist of curves, which lie across the surface-ice of the glacier, and extend from one side to the other The convexity of these curves is directed towards the lower end of the slope In the more elevated part of the glaciers the curvature is but gentle, but it increases in proceeding farther down, and towards the lower termination it presents a very elongated form Such curves can only be formed when an imperfectly fluid body runs down a gentle slope. The nature of the ice of which the glaciers consist is certainly in favour of this theory The interstices between the single crystals are possessed of a great capacity of absorbing water, and conducting it to a considerable distance When these interstices and also the air-bubbles which abound in the semi-opaque layers are completely saturated, it is very probable that the whole mass contains as much water as solid ice, and in that state it may be considered as an imperfect fluid, and moves slowly forward. But according to our knowledge of the laws of nature, we can only conceive the ice of the glacier to be found in such a state during the warm season. The progress of the glacier could, therefore, only take place during that part of the year From the statement of Professor Forbes himself, however, we must infer that the progress of the ice is hardly retarded in winter. In less than four months, from the 12th of December to the 4th of April, it advanced 142 feet If in four months complete it had advanced 160 feet, the progress in winter would have been as quick as in summer. In this extraordinary fact lies, in our opinion, the great difficulty, which must be removed before the theory of Professor Forbes can be considered as firmly established.

Among the inhabitants of the Alps the opinion prevails that the glaciers are continually on the increase, not in elevation, but in extent. They assert that the lower extremities of these icy masses advance farther and farther into the valleys, and on the declivities of the mountains, and they cannot overcome the apprehension that in time the ice will spread over some of their richest alpine pastures, and perhaps cover them entirely. It cannot be denied that there are many instances transmitted by tradition, and even a few recorded by history, which appear to prove that this fear is not quite without foundation Some mountain-passes and elevated valleys, which formerly were free of ice, are at present filled up; but all scientific men who have paid close attention to this subject, who have collected all the certain information regarding this supposed increase, and investigated the matter in all its bearings, are opposed to the opinion They account for the isolated instances of the increase of the glaciers by observing that, in some winters, the quantity of snow which falls is larger than usual, and that when such a winter is succeeded by a summer in which the temperature does not rise to its usual height, the whole quantity of snow which has fallen in the colder regions cannot be dissolved This may sometimes continue for several years in succession In such a case it is very probable that the whole mass of the glacier increases to a certain extent, and advances farther [illegible] the valley than it did before It may even happen that, under such circumstances, new glaciers of small extent are formed; but on the other hand it is also certain that, after some years, the reverse takes place. A smaller quantity of snow falls in winter, the mean temperature is higher, the winters are less cold, and then the new glaciers disappear, and the old ones recede within their ancient limits. According to another opinion, which however is less prevalent, the increase and decrease of the glaciers is subject to certain fixed periods It is maintained that each of them occupies the space of seven years. Saussure, however, rejects this statement, and

treats it as a fancy. According to his opinion, in this as in many other instances, nature operates with a certain degree of irregularity, which however does not materially affect the general order established by Providence in the universe.

There are perhaps no objects in nature which recompense the traveller more amply for the trouble of visiting than the glaciers, by their numerous and various beauties. These beauties are partly derived from their peculiar nature, and partly from the contrast they exhibit with the countries contiguous to their lower extremities. The immense extent of the huge icy masses, traversed in every direction by numerous yawning chasms descending to an unknown depth, and surrounded by turrets and perpendicular walls and cliffs of ice of the most fantastic forms, having in the background black rocks of an immense elevation, which rise in the shape of peaks out of a sea of extremely white snow, would fill the mind of the looker-on with horror were it not converted into astonishment and admiration by the peculiar bluish colour which spreads over the whole region up to the very borders of the snow-mountains, and attains in the chasms the deepest hue and greatest beauty. When the traveller turns his back, he finds the icy masses on which he is standing surrounded by forests, fields, pastures, and orchards. To his left is a meadow of the most verdant turf, on which flocks of sheep are feeding, attended by a shepherd, who tunes his flute or sings his pastoral lay. To the right is a gentle slope entirely covered with ripe barley, in which the reapers are busy collecting the bounteous gifts of Providence, whilst before him, on the banks of a river pouring down its whitish-green waters, stands a village of neatly-constructed houses, the abodes of happiness and content, surrounded by orchards in which cherries are found in abundance. At no great distance are a few groves of high forest-trees, mostly of the pine kind, which by their sombre aspect do not fail to impress a degree of earnestness on the cheerful landscape. At many places the scenery re-

ceives an additional zest by a small lake enclosed by meadows, from whose smooth surface the surrounding mountains are reflected, with their glaciers, snow-fields, and dark peaks. At another spot a cataract precipitates its silvery waters down the perpendicular declivities of a black rocky mass, the falling stream being frequently deflected from its straight line by a gust of wind.

None of the numerous glaciers of the Alps are better known than those of Grindelwald. They are annually visited by many thousand travellers, partly because they are more accessible than the others, and partly because they may be considered as fair specimens of the glaciers. They are two in number, and situated in the valley of Grindelwald, which lies in the high mountain-masses extending between the cantons of Berne and Valais. This valley extends from north-west to south-east, and on both sides the higher part of the mountains rises above the snow-line. In the north-eastern chain is Mount Faulhorn, which rises to 8547 feet above the sea-level. The south western chain is much more elevated, being overtopped by Mount Wetterhorn, 12,177 feet high; Mount Eigher, nearly 13,000 feet high; and the summits of Schreckhorn and Wisherhorn, which are still more elevated. The valley is at the village only 3357 feet above the sea, and therefore well inhabited. In and near it are numerous orchards of cherry-trees, well-cultivated fields, and large pasture-grounds The two glaciers are situated at its upper end The lower is smaller, and lies between Mount Eigher and the Mettenberg: the larger between the last-named mountain and the Wetterhorn. They lie parallel to each other. The lower one is the more beautiful, as it descends over a much more broken surface, and consequently presents a much greater variety in the icy masses with which its surface is studded To the south and east of the Valley of Grindelwald is a mountainous country of the extent of the county of Middlesex, if not larger, which may be considered as one large glacier (for the numerous glaciers which occur in this tract are separated from one another only by ridges

of snow-capped mountains), on whose back are placed a great number of high peaks, among which Mount Finsteraarhorn is the highest. It rises to 14,100 feet above the sea. Nearly as numerous are the glaciers which descend from the western base of Mont Blanc, south-east of Geneva. They lie so close together that they appear to constitute one immense mass of ice, to which the name of Mer de Glace, or Sea of Ice, is not improperly applied

Section III.—Avalanches.

Avalanches are masses of snow or ice which fall from the upper declivities of high mountains into the valleys at their base, often occasioning damage, and destroying life and property. They are very frequent in the Alps, but occur also in the Pyrenees, Norway, and in all countries in which mountains rise to a great elevation. Some of them originate in those parts of the acclivities which are contiguous to the snow-line, but others at a much less elevation. When the accumulation of snow on the declivities becomes so great that the inclined plane on which the mass rests cannot any longer support it, it is carried down the slope by its own weight, and precipitated into the subjacent valley, destroying forests and villages, burying men and cattle, and sometimes filling up the rivers and stopping their courses. Besides what is actually covered by these falling masses, persons are often killed and houses overthrown by the sudden compression of the air caused by the incredible velocity with which some of the avalanches descend.

If we examine the manner in which these dangerous and terrible phenomena originate, we may distinguish four kinds of avalanches: drift avalanches, sliding avalanches, creeping avalanches, and ice or glacier avalanches.

The *drift avalanches* are composed of loose snow; they can only originate when the quantity of snow is very large, and has been lodged on a steep declivity, whence it is dislodged for want of support. The mass in falling loses its coherence, on account of the imperfect manner in which its particles have been united, or by striking violently against projecting rocks. These

avalanches commonly take place in winter, when a very heavy fall of snow has occurred in the higher regions during a calm Great masses are then lodged on declivities, which are sufficient to afford a support to them during calm weather, but not when the atmosphere is agitated by strong gusts of wind Such winds, which are not rare at that season, detach the uppermost mass from the declivity of the mountain, and bring it down on other masses which lie lower, which in their turn are forced off, and thus an enormous volume of snow is collected before it reaches the valley For a long time it was the prevailing opinion that they owed their origin to small balls of snow, which were formed near the upper edge of the most elevated snow-mass, and which in rolling down the declivities were increased to such an enormous size as to produce by the violence of their fall the most extraordinary effects This opinion arose from the vulgar, but generally diffused idea, that a loud sound, or the tinkling of a bell, was able to bring down the enormous masses of snow which cover the upper regions of the mountains As these avalanches always descend quite unexpectedly and without any apparent cause—the gust of wind not being perceived in the deep valleys—people were unable to assign any sufficient reason for their formation * This opinion of the origin of these avalanches prevails not only in the Alps but also in the Himalaya mountains, and in the Hindu-coosh On a closer examination, however, it has been found that strong gusts of wind originally impart the first impulse to these masses of snow, and that they acquire their size by uniting with other masses lying lower down The incredible velocity with which they descend, and the immense force with which they strike, prove that the drift avalanches must originate at a great elevation. They are very much dreaded, not so much on account of the damage caused

* They thought that they must be produced by a very trifling motion, and therefore adopted the above-mentioned idea of a moving ball, occasioned by the alighting of a bird, or the sound of a bell.

by the snow itself, as from the effects of the compression of the air, with which they are always attended. The air compressed by these masses rushes off on all sides with the greatest velocity, and with a force able to break off huge pieces of rock, to uproot the largest trees, and to scatter houses like chaff. It is very fortunate that the drift avalanches are of rare occurrence, and that they rarely descend to those valleys which are thickly peopled and well wooded.

The *sliding* avalanches, though less destructive in their effects than the drift avalanches, cause greater damage than the others, on account of their frequency. They take place when the snowy covering of the declivities, by having been slightly thawed and again frozen, has acquired a considerable degree of consistency on its surface, and has been cemented to some extent into one mass. When under such circumstances, by the natural heat of the earth, the bond has been loosened which unites the mass to its base, and the ground on which it rests has been rendered slippery, the whole mass begins to slide downwards in one sheet, and precipitates itself over every obstacle into the valleys. These avalanches originate in the middle regions of the mountains, on declivities which have not a very rapid slope, and in spring time. They are less dangerous because they are not attended by a compression of the air, but they cause great damages by the enormous masses of snow which they bring down. These masses are sometimes so great as to cover large extents of meadow and forest with such a thick layer, that several summers must pass before they are entirely melted; this affects the climate of the valley in a very disadvantageous way. But they also frequently cause considerable loss of life and property. In the year 1749 the whole village of Bueras, in the valley of Tawich, in the canton of the Grisons, was buried under, and at the same time removed from its site by, an avalanche of this description. But this change, which happened in night-time, was effected without the least noise, so that the inhabitants were not aware of it, and on awakening in the morning could not

conceive why it did not grow day. One hundred persons were dug out of the snow, sixty of whom were still alive, the hollows within the snow containing sufficient air to support life In 1806 an avalanche descended into Val Calanca, likewise in the canton of the Grisons, transported a forest from one side of the valley to the other, and planted a fir-tree on the roof of the parsonage-house Several villages have been destroyed by these avalanches, and a large number of persons and cattle have been killed But in general th do not come on unexpectedly The places where they frequently occur are known, as also what kind of weather commonly precedes their descent The Austrian government, some years ago, wishing to connect the province of Sondrio with Tyrol, by a mountain road which was not to pass over any portion of Switzerland, but to be entirely within their own dominions caused a road to be made over Mount Stelvio through a region frequently exposed to sliding avalanches Notwithstanding the extreme care with which the galleries were constructed, which were to protect the road and the passengers against them, the snow descended in such enormous masses as to break down all the galleries, and compelled the Austrian government to give up the plan This is the only kind of avalanche which occurs in Norway, the shape of the mountain-masses in that country not being favourable to the formation of the other kinds But as nearly all the mountain-masses have along their borders gentle declivities of considerable width, they are frequent and destructive in that country A few years ago a number of reindeer, exceeding fifty, were found dead in a narrow and uninhabited valley, within a narrow space, which according to all appearances had been buried by an avalanche

The *creeping* avalanches are called in Switzerland *suoggi* (pron suggy), from a verb suogger, which signifies to advance slowly, to creep. They originate in the same manner as the sliding avalanches, but on declivities which have a much more gentle slope The snowy covering when loosened from its rocky base begins to move

slowly down the slippery declivity, and to carry before it everything which is too weak to withstand its pressure. When an object does not directly give way to its mass, it is either borne down by the snow accumulating behind it, or the whole mass divides, and proceeds in its course on each side of it These avalanches are very frequent, but rarely cause any considerable damage, from the comparatively small volume of snow they bring down, and their slow advance They occur mostly in spring, and on the lower acclivities of the mountains.

The *glacier* or *ice avalanches* are nothing but large fragments of glaciers, and their origin is especially due to the fracturing of the icy masses, when they are protruded downwards. They are frequently broken into small pieces by other masses of ice, or by rocks which they meet in their progress When in such a state and seen from a distance, they resemble the cataracts of a powerful stream. In summer, which appears to be the only season in which they occur, they may every day be seen on almost all the glaciers of Switzerland, and at the base of Mount Jungfrau, in the valley of Lauterbrun, in the canton of Berne, the thunder which accompanies their fall is almost continually heard They are not in general destructive, because they descend upon places which are not inhabited Yet occasionally their fall is attended with terrible effects This is especially the case when a glacier terminates on the very edge of a high mountain-mass, which descends with a perpendicular declivity into an inhabited valley A very dreadful catastrophe of this kind occurred in 1819 in the valley of Visp in Valais, where the village of Randa was destroyed by a glacier avalanche. This village was built not far from the base of a mountain-mass, which rises nearly perpendicularly to an elevation of more than nine thousand feet above its base, and forms part of the snow mountain called Weisshorn (white horn), which is everywhere surrounded with huge masses of glaciers. One of these glaciers had advanced to the very edge of the precipice, and was overhanging it, when at once an enormous piece of it was detached, and with a terrible crash

precipitated down into the valley, where it covered with ice, rubbish, and fragments of rock an area of two thousand four hundred feet in length, and a thousand feet in width, to a depth of more than a hundred and fifty feet. This mass fell on an uninhabited tract, but in its vicinity was the above-named village, which was destroyed by the compression of the air produced by the fall of that enormous mass The force of the gust caused by this compression was so great, that it raised millstones from the ground and lodged them on a slope which was several yards above the place where they had been deposited It conveyed the beams of several houses to a distance of nearly a mile into a forest, and broke down the steeple of the church, which was a massive building of stone.

The year previous to this event a catastrophe of a different description was produced by glacier avalanches in another valley of Valais, the vale of Bagnes The upper basin of this valley, which is drained by a river called the Drance, is uninhabited on account of its cold climate, being much elevated and besides surrounded by glaciers. This basin is divided from the lower and inhabited part of the valley by a narrow gorge, on one side of the gorge stands Mount Mauvoisin, which terminates at a short distance from the Drance in a nearly perpendicular rock about five hundred feet high, and whose upper part is occupied by a glacier called Getroz. On the opposite bank of the river stands another high rocky mass The gorge formed by the two mountains is not quite half a mile wide In 1811, the masses of ice and the avalanches falling down from the glacier were so numerous and large, that the summer heat did not dissolve them. They accumulated and formed a glacier in the gorge itself. This glacier went on increasing up to 1817, when it extended over the bed of the rivulet—for such only the Drance is at this spot—and stopped its course. The consequence was that a lake began to collect behind the ice barrier, which soon attained a depth of fifty feet. But no danger was apprehended when it was discovered that the water of the lake was discharged by an opening under the glacier. This opening was

unfortunately shut up by an avalanche from the Getroz glacier in 1818. The lake behind the ice barrier soon increased to eight thousand feet in length and two hundred feet in depth The ice barrier itself which prevented the water of the lake from running off, was five hundred feet long, about one thousand feet broad, and where lowest upwards of two hundred and twenty feet above the surface of the lake The waters, however, receiving continually a large supply from the melting snow of the very extensive Chermontane glacier, increased rapidly, and from the 14th to the 24th of May the surface of the lake rose nearly twenty-three feet. The inhabitants of the lower valley, who for some time previously had begun to pay attention to what was going on, became now alarmed, considering the dangers to which they would be exposed, if the ice barrier should give way to the pressure of the water behind. They recollected that in 1545 a similar event had laid waste the whole valley and drowned the village of Bagnes with one hundred and forty persons They accordingly applied to the government for assistance, and suitable measures were directly taken to prevent such a misfortune A horizontal gallery was cut through the ice barrier, six hundred feet long and fifty feet above the surface of the lake It was thought that this elevation above the water was sufficient to allow time to finish the work before the lake could attain this height • When finished it was supposed that the new supplies of water would be carried off by this gallery, and that afterwards the water itself would dissolve the ice over which it ran, and by thus gradually deepening the cut, would also lower the surface of the lake The operation was difficult and doubtful in its effect, but as the danger was certain and imminent, the work was pursued with great activity. The cut was finished on the 13th of June, no sooner was it terminated than the water which in the mean time had risen to the level of the cut, began to flow off through the opening, and all danger seemed to be averted. On the 16th of the month the water of the lake had already sunk forty feet, and the cut had been considerably deep-

ened by its rush. But on the same day the water opened another road near the declivity of Mount Mauvoisin, at a place where the glacier rested on some loose pieces of rock, which not being able to withstand the pressure of the water, suddenly gave way. An enormous volume of water rushed at once into the valley; it amounted according to the public account to five hundred and thirty thousand cubic fathoms. In less than half an hour it had overwhelmed the village of Bagnes, and in a shorter period it proceeded from Bagnes to Martigny. It reached the Lake of Geneva, which is about sixty miles distant from Mount Mauvoisin, in five hours and a half. It was a happy circumstance, that the water of the Rhone was uncommonly low, so that the bed of this river was capable of containing the whole of the water, and carrying it into the Lake of Geneva, otherwise the inundation of the lower vale of the Rhone would have considerably increased the loss of property. Although signals were immediately made to acquaint the inhabitants with this event, yet about fifty persons lost their lives. Not only houses and barns were carried away, but even extensive forests, and at some places the soil lying upon the rocks was entirely washed off, so that nothing remained but the bare stone. The damage was very great, and estimated at upwards of 40,000*l*. It is however supposed that it would have been much greater, if the cut had not been made through the ice barrier, for in that case the volume of water which would have collected behind it would have been twice or thrice as large, and the damage caused by it in proportion.

Section IV.—Mountain-slips.

Effects even more disastrous than those of the avalanches are sometimes produced by mountain-slips. Persons who have passed some time in the Alps know very well that frequently smaller fragments of rocks roll down the sides of a steep acclivity, so that those who are ascending are sometimes hurt by coming in contact with them. This, of course, takes place more frequently in mountains which present only a continual alternation of descent and ascent, valleys and ridges, ravines and depressions, and less in those where the mountain-mass extends in a level plain, with but a slightly broken surface. On that account rocky fragments rolling down from the acclivities are rarely met with in Norway, except on the steep masses which lead to the table-land, but they are of daily occurrence in some parts of Switzerland. In the last-named country it sometimes happens that huge masses of rock, crowning the summit of very elevated peaks, descend into the contiguous lowlands, which are many thousand feet lower, and it may easily be conceived that such mountain-slips are almost always attended with the most destructive effects to the countries on which they descend, and to their inhabitants.

It is natural to inquire, in what manner such enormous masses, which sometimes are more than a hundred thousand tons in weight, can be removed from their situation on the top of the mountains, and hurled down to their bases. It is effected by a very slow process of nature. It must, however, be premised that it can only take place in mountains which are stratified, that is, which consist of layers of rocks of different kinds. For when the whole mountain is composed of one kind of rock,

which is not stratified, no mountain-slip can occur, though small fragments of it may occasionally be detached and fall down When, on the other hand, the strata of a mountain consist of different kinds of rock, it may sometimes be the case that the uppermost stratum is less subject to destruction by water than that on which it rests If under such circumstances the water finds its way through the uppermost stratum, either by rents, which frequently occur in some kinds of rock, or otherwise, it destroys by degrees the lower stratum, carrying off the component particles by torrents, or descending along the rents to the adjacent country In this manner the whole of the uppermost stratum may be undermined in the progress of time It loses its base, or at least its principal support, and sinks down on that stratum which was contiguous to that which has been washed away If the inclination of the last mentioned stratum is but slight, no other change commonly takes place, and perhaps no signs of alteration are observable in the uppermost stratum But if the lower stratum has a considerable inclination, the uppermost stratum slips down from the inclined plane The greater the difference is between the summit of the mountain and the country at its base, the greater must be the velocity which the mass attains before it reaches the lower level In such a case, as may well be conceived, the mountain-mass is broken into numerous pieces, and overwhelms the low country with its ruins This is the most common case But it sometimes also occurs that the uppermost stratum itself does not present throughout its whole surface a uniformity in its texture, but that some portions of it are more subject to disintegration than others In those parts which are more easily destroyed by water, some holes and rents are soon formed, which, continually increasing, gradually take the form of chasms of considerable width In such depressions water is lodged, which by its weight, and especially when converted into ice, presses against the sides of the chasm, and strives to remove them. In this way single but large pieces of rock may be removed from their site; and if by chance

they are standing on the edge of a precipice, they lose their support, and are precipitated down to the lower region.

These mountain-slips are much more frequent than is commonly thought. But as most of them happen in valleys which are not inhabited, or serve only as pasture-ground during a few months of the year, the damage caused by them is not great, and they pass unnoticed. But there are some instances on record where mountain-slips have been attended by the most disastrous effects More than two hundred years ago a small but rather well-built and pleasant town existed in Val Bregaglia, which at present forms part of the Lombardo-Veneto Kingdom. On the 4th of September in 1618 this place, with an adjacent village, was buried under the ruins of Mount Conto, at the base of which it was standing The number of persons who lost their lives amounted to 2430 Only three of the inhabitants of the town were saved, because they had left it on some business; and only one house remained standing The course of the river Mera, which washed its walls, was stopped for two hours, but fortunately it worked its way through the ruins and rubbish For the ten years previous to this catastrophe it had been observed that several large chasms had been formed on the side of the mountain, but nobody paid much attention to them From the 25th to the 29th of August there were very heavy falls of rain, and again from the 1st to the 3rd of September. These were considered as the immediate causes of the slip. On the 4th the weather was serene and pleasant, but in the afternoon some rubbish, composed of rocky fragments, came down from the side of Mount Conto. In the following night, whilst the air was quite calm, and the sky cloudless, the summit of the mountain rushed down with a most terrible crash, and buried the town At present the ruins of the mountain are overgrown with a forest of chestnut-trees

Where the cantons of Valais and Pays de Vaud border on one another is a table-land, which is so elevated that

its surface is partly covered with snow and partly with glaciers Out of this great snow-field rise the Diablerets or Devilshorns, large and very pointed peaks, which attain an elevation from 10,000 to 11,000 feet above the sea-level. At present there are only three of them, but in the beginning of last century there were four. One of them has slipped down, and scientific persons who have examined the country in this vicinity have found it covered to such an extent with broken pieces of rocks, stones, and rubbish, that they have come to the conclusion that in remote times their number must have been still greater The peak did not slip down at once, but one part fell in 1714 and the other in 1749 Before the first catastrophe a subterraneous noise was heard, and some of the herdsmen, who had brought their herds to the pastures in the vicinity, took this hint and returned home; others, however, were buried under the rocks When the mount precipitated itself down, the whole country in its vicinity trembled, and a thick smoke rose to a considerable height in the air It was only dust, which was detached from the rocks when they broke to pieces. The compression of the air was so great that some of the trees which were near the places along which the rocks descended were bent to the ground or broken Many of the summer huts of the alpine herdsmen were destroyed, fourteen persons lost their lives, and a large number of cattle and sheep were killed

One of the herdsmen belonging to the village of Aven in Valais was among those who had not returned home, and was considered as having lost his life. His children were declared orphans by the court Three months afterwards, on Christmas-eve, he suddenly appeared in his village—pale, thin, covered with rags, resembling a spectre. All the inhabitants of the village were frightened. The doors of his own house were shut to him Some people ran to the priest, requesting him to exorcise the supposed spectre. After some delay the man succeeded in convincing the people that he was alive, and then he told them that in the moment on which the mountain-slip took place he had been on his knees,

praying to the Preserver of life, when an enormous fragment of rock, in descending, struck the ground before his hut, and resting, leant over against the rocky wall at the base of which his hut was built. It was immediately followed by a terrible crash, and by an immense quantity of stones and rubbish, entirely covering the piece of rock which protected his hut. When all became quiet, he continued, "I was no longer in fear, I did not lose my courage, and directly I set myself to work to open an issue. A few pieces of cheese, which I had made, were my food, and a rill of water, which descended among the ruins, quenched my thirst. After many days, which I was unable to count in the long darkness of my subterraneous prison, I discovered, by creeping about among the rocks, an opening. I saw again the sun's light, but my eyes were for some time unable to bear it. The Almighty, in whom I always confided, and who always kept alive my hope of preserving life, has sent me back to my family, to be a witness and a proof of his power and bounty."

The second mountain-slip of the Diablerets, which took place in 1749, was attended by the same phenomena. None of the inhabitants of the vicinity lost their lives, as all of them had removed from their places as soon as the subterraneous noise from the mountain was heard. But five citizens of the canton of Berne, who were in the neighbourhood on business, heeding not the admonition of their host, were buried under the ruins, and it is thought that the house in which they were is five hundred feet under the present surface. So large was the quantity of rocks, stones, and earthy matter brought down by this mountain-slip, that it covered a great extent of good pasture-ground, which continues to this day to be a mere waste.

The most remarkable of these mountain-slips occurred in the beginning of this century, in 1806, and as it happened in a part of Switzerland which perhaps is visited more than any other by every species of traveller, our information respecting the catastrophe is more complete and correct than on those which have taken place in

more remote times, or at places not much visited by foreigners By this mountain-slip the Vale of Goldau, to an extent of more than three miles in length, and all the contiguous slopes, were covered with rocks, and five villages, with their inhabitants, buried under the ruins

The Vale of Goldau, as it is still called, extends from north-west to south-east about six miles On its north-eastern side stands Mount Ruth, also called the Rossberg, which rises to 3747 feet above the Lake of Zug, and on its south-western side Mount Righi, so well known to all those who have visited Switzerland, as hardly any person omits ascending its summit for the pleasure of enjoying a view, which for beauty, variety, and grandeur does not yield to any other known on the surface of the globe The summit of Mount Righi is 4644 feet above the level of the Lake of Zug The Vale of Goldau, which lies between these two mountains, consists of two inclined planes of nearly equal extent, of which one terminates on the north-west, on the banks of the Lake of Zug, and the other descends to the northern extremity of the Lake of Lowerz, which is of smaller dimensions than that of Zug Both the above-named mountains are stratified, and consist of conglomerate, that is, their material is composed of rounded and smooth fragments of stone of various kinds and different size, from the smallness of a single grain of sand to pieces containing fifty cubic feet. This material is cemented together into one mass, either by a kind of sandstone or by a fine-grained marl The strata are of different thickness sometimes amounting to several hundred feet Mount Ruth has along its northern declivity a steep descent, but towards the Vale of Goldau it has a more gradual slope, presenting in general a plane, which forms an angle of 25° with that of the horizon, whilst Mount Righi rises from the vale with a steep acclivity, and its strata have their inclination directed to the south

More than fifty years before the catastrophe of 1806 large rents had been forming in the mountain mass of Mount Ruth, along its southern declivity, which by degrees attained a great depth, and by which water was

continually penetrating into the interior of the mountain. It appears that these rents passed through the uppermost stratum of the conglomerate, which was united to that on which it rested only by a layer of marl and clay. This was washed away by the water, which was copiously conveyed by the above-named rents The snow-falls in the winter preceding the catastrophe had been uncommonly heavy, and much rain had fallen during the months of July and August On the 1st and 2nd of September the rains were incessant, and very abundant. The attention of the inhabitants of the vicinity had been roused, on the morning of the 2nd September, by some unusual noises proceeding from Mount Ruffi, which became more frequent in the afternoon, and also by some pieces of rocks, which descended from its declivities Towards five o'clock in the evening some much larger masses of rock detached themselves from the summit of the mountain with a loud crash, and descended to the lower grounds A few minutes later a horizontal rent became visible, which passed throughout the upper part of the mass, at a great distance from its summit; and, at the same time, a portion of the mountain, with its forests and buildings, was seen to be in a slow motion towards the lower grounds. The spectators were put into a great consternation at this sight, and when they raised their eyes towards the summit of the mountain, they saw the whole mass which was above the horizontal rent detach itself from its base, and begin to move downwards. at first slowly, but its velocity increased rapidly, and at last it rushed down with a most frightful crash At this time the air was filled with clouds of dust, which prevented the observers from tracing the farther progress of the masses As these persons were standing near the base of Mount Righi, on an elevation of about 300 feet above the vale, they thought themselves out of the reach of any danger from the descending rocks, but they soon observed that a torrent of rocks approached the house in which they were. Large fragments, many hundred pounds in weight, were hurled by the great impulse which they had received by their fall from the

summit of Mount Ruffi, to the hill, which they ascended, rebounding until they stopped at a short distance from the persons who witnessed this horrible phenomenon

Such is the account of eye-witnesses. In examining it, it is evident, according to the laws of nature, that two slips had taken place, which must be distinguished The whole process began with the slip of the lower and less inclined declivity It is probable that the upper stratum of this declivity, too, had been loosened from its base by a marly or mouldy layer having been removed by the water. As soon as the motion of this mass had commenced, the horizontal rent under the summit of Mount Ruffi was observed That portion of the summit which, by the removal of the lower declivity, had lost its support, began to detach itself from its base by inclining towards the south, and thus originated the visible rent Then the summit tumbled down, by which the most elevated part was hurled to the greatest distance Immense pieces of rocks, which had been lodged there, were flung over the lower ones, and carried to the base of Mount Righi The descent of the lower declivity was properly a mountain-slip, and that of the summit a mountain-fall.

The mountain mass had come to the ground in the middle of the vale, at a nearly equal distance between the two lakes, and at this place, at present, a ridge of some elevation is found, which is crowned by many rocks of huge dimensions, rising in the form of peaks above it. Several of these rocks are so immense, that a large building could be hewn out of them From this ridge the smaller pieces and earthy matter have rolled to the north-west and south-east On its descent to the north-east, they overlaid the village of Goldau, and on the south-east that of Busingen, and in part also the village of Lowerz. Ober and Unter Rother were villages built nearer the base of the mountain, and had first been buried under its ruins. A portion of the matter which descended to the south-east filled up a part of the Lake of Lowerz. The velocity with which it fell into the lake caused two or three large waves, during which the

water rose above the island of Schwanau, though it is sixty feet above the level of the lake, and rushed with great violence over the lower portion of the village of Seven, which stands on the banks of the lake, about two miles' distance from the place where the stony masses entered its waters All the buildings of stone which were reached by the waves were destroyed. The extent of the country covered with the stones and rubbish between the two lakes is about three miles, and in the opposite direction it is still greater. Its area probably exceeds ten square miles

Some pains have been taken to determine the size of the rocky mass which was hurled down from the summit of Mount Ruffi, but that has been found impossible for obvious reasons. Its width has been estimated to have been somewhat less than three furlongs near the summit, but towards the lower extremity it must have been much greater Its thickness was very various, and cannot be ascertained in most places Towards the eastern extremity it amounted to more than two hundred and fifty feet. According to a vague statement it was nearly three miles long

In five minutes—for the whole catastrophe did not take up more time—the beautiful and well cultivated Vale of Goldau, with its fields, orchards, and pastures, was converted into a waste The government of the canton of Schwyz has been at considerable pains to ascertain the extent and amount of the damage produced by this mountain-slip It was found that the number of dwelling-houses which had been destroyed amounted to ninety-seven, and that besides eight others had been greatly damaged The number of stables and other out-buildings which had been buried and broken down was one hundred and sixty-six, and nineteen others had suffered more or less Four hundred and eighty-four persons lost their lives, and one hundred and ten head of cattle, and one hundred and three head of sheep and goats, were killed. Among those who perished were sixteen persons who were not inhabitants of these places, but had come there on business or for other purposes.

The whole amount of the loss of property, according to very detailed accounts, was, on the lowest estimate, equal to nearly 90,000*l* sterling

Scientific persons, who have closely examined that portion of the summit of Mount Ruffi which has remained standing, are of opinion that in the progress of time it may also be hurled down by a similar process of nature, and, in fact, a comparatively small piece broke loose in 1823, and fell on those places which formerly had experienced that fate A small chapel has been built on the place where formerly the village of Goldau was standing, in which the pious Swiss annually convene on the 2nd of September, to pray God to preserve them from a repetition of such a frightful catastrophe

Section V.—The Icebergs and Ice-fields.

It must be in the remembrance of the reader, that in 1841 a large steam-vessel, the President, which had left New York for England, did not arrive at the place of its destination, and has not since been heard of. There is no doubt that it has been destroyed, but none of the crew and its numerous passengers escaped to give an account of the circumstances which led to its destruction. When it had become a certain fact that the vessel had been destroyed, the relations of those who had perished, and other persons who took interest in their untimely end, began to start conjectures by which they tried to account for the loss of the vessel. After maturely considering all the probabilities, the conclusion was come to that the President must have got between large masses of ice, by which it was crushed to pieces. That such an event is far from being beyond the limits of probability, may be inferred from what happened in 1821 to the brig Anne of Poole. This vessel, on its return from Newfoundland to England, left Greenspond on the 19th of January, and in the evening of the same day it encountered several floating islands of ice. On the following morning by sunrise the ship was so completely beset with ice, that no means of escape were visible, even from the top of the masts. The ice in its whole extent rose about fourteen feet above the surface of the water. It drifted towards the south-east, and bore the ship along with it for twenty-nine successive days. It was only on the 17th of February that the captain perceived an opening to the south-east, by which he made a successful attempt to disengage the vessel.

In the year in which the President was lost, the Atlantic Ocean was more thickly beset with icy masses,

and at an earlier season, than commonly takes place. This we learn from a report of the Great Western, which was published in New York. This steamer left England towards the middle of April, and met between 42° and 43° of latitude, and between 48° and 50° of longitude, with an icefield which extended for more than a hundred miles in the direction from east to west, and the vessel proceeded along the southern edge of this mass on the 18th and 19th of April. This edge was lined by a broad border of loose ice, consisting of numerous floes and icebergs, and a great quantity of drift-ice. To make its way through these floating masses the steamer was frequently compelled to change the direction of its course, lest it should come in contact with some of them and be damaged. The number of icebergs which were in sight of the vessel amounted, as it is stated, to about three hundred, and the largest was three-fourths of a mile long, and about a hundred feet high. Several others rose to an elevation of from seventy to a hundred feet. The ice-field itself was raised from two to four feet and a half above the level of the sea. In approaching any one of the larger masses the temperature both of the air and of the water was considerably depressed, the first descending to 28° and the second to 25° Fahr. Other vessels traversing the same part of the ocean later in the season found icebergs still there, and it is stated that one of them rose, according to an estimate, to from two hundred and seventy-five to three hundred feet above the sea, and extended from half to three-fourths of a mile.

According to these accounts a very large *ice-field* was met with in the Atlantic south of 45° of latitude. This is certainly a very uncommon event. There is no other instance on record of such fields having ever been met with at so low a latitude, though they are frequent farther to the north. But it is a well established fact that every year large *icebergs* are found in the Northern Atlantic as far south as 40° of latitude. They however do not occur in every part of this portion of the sea, but are limited to the tract which lies between 42° and 50° of longitude, so that they are met with somewhat nearer to

the shores of the United States than to those of Europe. They have never been seen east of 42° of longitude, except in 1817 In this last-mentioned year an uncommon event took place. A large body of ice, many thousand square miles in extent, which for time out of memory had constantly occupied a space north of Iceland, suddenly was broken up, and its fragments were scattered over the northern Atlantic. [It will be remembered that this circumstance led to the expeditions of Captains Ross, Parry, Franklin, and Beechey For as soon as it was known that the ice had disappeared from this region, it was considered probable that by this event the sea had been rendered navigable all the way to the Pole] In this year single but large pieces of ice were found as far east as 32° of longitude, or at a distance of about eight hundred miles from the western shores of Ireland

The icy masses which are found floating in the sea are of two different descriptions, and each of them appears to originate in a different way. They are either *sheet ice* or *icebergs*. The sheet ice bears a strong resemblance to that with which the rivers of the northern countries are annually covered Its upper surface is level, or nearly so, and it is only here and there diversified by low hillocks. When such a sheet of ice is so extensive that its limits cannot be discerned from a ship's mast-head, it is called a field, and these *fields* sometimes cover an area of a hundred square miles, and more. When their extent can be seen from a ship's mast-head they receive the name of *floes* Masses of floating ice of this sheet kind, of various shapes and magnitudes, up to a quarter of a mile in diameter, are called *drift ice* On the level surfaces of the sheet ice some protuberances are frequently observed rising at times to the height of thirty feet and upwards above their base They are called *hummocks*, and are produced by pressure, when two fields meet one another Then the edges of the ice-fields are broken, and these fragments are squeezed upon the ice, where they are set upon their edges, and in that position are cemented by the

frost. The thickness of heavy fields is from ten to twenty feet, and they are commonly raised from two to eight feet above the level of the sea. But that part of the field which is above the surface of the water consists partly of snow, for before the month of July it is always found covered with a bed of snow from a foot to a fathom in depth. This snow dissolves by the end of the summer, and forms on the surface of the fields extensive pools and lakes of fresh water.

The other kind of icy masses floating in the sea are the *icebergs*. They project above the surface of the sea like high hills composed of rugged and steep rocks. Some of these masses are of immense size. Navigators have frequently stated, that they have seen icebergs rising from four hundred to five hundred feet above the surface of the sea and extending more than a mile in length. It may, however, be supposed that in such cases some exaggeration has entered into the account, or that an optical deception has taken place, which cannot be a matter of surprise when it is considered that these icy masses are commonly met with in seas where the refraction of light is very unequal, and produces the most extraordinary phenomena. Keeping to facts which have been well ascertained, we find that during the first voyage of Captain John Ross, Lieutenant Parry measured an iceberg which was aground in Baffin's Bay in sixty-one fathoms of water. It was 4169 yards long, 3689 yards broad and 51 feet elevated above the sea. Its weight was calculated to be equal to 1,292,397,673 tons. Captain Graah, the Danish navigator, examined an iceberg on the eastern coast of Greenland, whose circuit at its base he estimated at 4000 feet, and which rose 120 feet above the sea-level. He calculated that its contents amounted to more than nine hundred millions of cubic feet. The icebergs differ greatly in shape. The most general form is with one high perpendicular side, the opposite side being very low, and the intermediate surface forming a gradual slope. Some few of them have regular flat surfaces, but usually they terminate in acute summits, exhibiting the most fantastic shapes and

an astonishing variety in form and appearance Some of them resemble palaces or churches, or old castles with spires, towers, windows, and arched gateways, others pyramids and obelisks, whilst others exhibit a great resemblance to ships, trees, animals, and human beings; a number of them seen at a distance of a few miles present the appearance of a mountainous country, and have frequently deceived the eyes of experienced navigators. They differ a little in colour according to their age, solidity, or the state of the atmosphere A very general appearance is that of cliffs of chalk, or of white or grey marble. A few have a bluish or an emerald-green colour The sun's rays reflected from them sometimes give a glistening appearance to their surface, so that they appear to be made of silver In the night they are readily distinguished even at a distance by their natural effulgence, and in foggy weather by a peculiar blackness of the atmosphere Thus the danger with which the navigator is threatened by them is much diminished.

The origin of the icy masses floating in the sea has, for a length of time, been a point of controversy among natural philosophers In observing the process of nature in forming ice it has always been found that at first the water contiguous to the shores of the sea or the banks of the rivers and lakes was converted into its solid form. Hence it was concluded that the vicinity of land was an indispensable condition for that purpose, and this principle was also applied to the formation of the ice floating in the sea It was supposed that all these bodies of ice had originally been formed along the shores of the contiguous land, whence they had been detached by the waves and the swell of the sea When floating in the sea, they had by degrees obtained their immense size, especially by the frost's cementing several pieces together into one large field. But there arose a doubt respecting this fact, when the immense quantity of ice was considered which annually flows down from the Poles to the lower latitudes, and which is dissolved and dissipated by the action of the waves and the warmth of the climate into which it drifts. Nevertheless, no diminution of the supply is

observed, which certainly could not be so great, if all the ice was to originate along shores of a comparatively not large extent It is therefore probable that the ice is formed in the open sea, though we are unable to explain the manner in which it takes place This cannot be a matter of surprise, when it is considered that we are not better acquainted with the manner in which the floating ice of rivers originates, though the operation of nature in these waters is placed much nearer to the observation and examination of the philosopher It is certain that in the rivers too the floating ice is not originally formed along the banks, but where and how cannot be determined

These doubts respecting the formation of the ice in the sea have only reference to the sheet ice, for as to the icebergs it has been ascertained, beyond all doubt, that they originate on the land, being nothing more than *large fragments of glaciers* By far the larger number of them, as it appears, originate on the coasts of Greenland, south of 67° and 68° of latitude As far as we have any information respecting the interior of this part of Greenland, it presents nothing to the view but a succession of mountains rising far above the line of congelation They are consequently always covered with snow. The valleys and depressions which occur between them are filled up with ice, derived from the higher portions of the mountains, and thus converted into immense glaciers In this manner a country of many thousands of square miles is buried under masses of perpetual ice and snow, the depth of which nobody is able to ascertain. It is easy to conceive what a refrigerating power such immense and uninterrupted masses of snow and ice must exercise on the contiguous countries Where the mountains terminate, their declivities are overlaid with glaciers of great depth It is true, on the western shores of Greenland the glaciers only advance at a few places so far as to front the open sea. The mountains sink there generally to a low level at a distance of many miles from the sea-shore, and the intermediate country exhibits only isolated masses of rock, between which are some level

tracts free of snow in summer, on which the scanty population of the country have settled. But even on the western coast of Greenland are several places where the mountains, and with them the glaciers, extend to the very margin of the sea On the eastern shores the masses of ice almost everywhere advance close to the water's edge, and at a few places only a space is left large enough to haul up a boat. These glaciers do not confine themselves to the land, but in most places they encroach on the dominion of the sea, and extend for many hundred feet over its depth, so that the eastern shores of Greenland are almost continually lined with cliffs of ice rising several hundred feet above the base in the manner of a wall. On the western coast, as we observed, only a few glaciers front the open sea, but the continuity of its shores is interrupted by a great number of long friths, which run far inland, and which are surrounded either entirely or in great part by glaciers If the extent of all the shores of Greenland, in which the glaciers advance to the very sea, were put together, it is probable that they would constitute a coast-line exceeding six hundred miles in length These are the birthplaces of the icebergs In giving an account of the glaciers (p 33 and 34) it was stated that these masses of ice advance every year, probably in consequence of a pressure which proceeds from the interior of the snow-mountains, on which they are dependent This evidently takes place also on the shores of Greenland. The glaciers advance farther and farther into the sea, but the sea undermines slowly and gradually the base on which the advanced portion of the glacier rests When this has taken place to some extent, and one of the disruptions occurs, to which the glaciers are frequently subject, that portion of it which is not supported by a firm base detaches itself entirely from the main body, and is precipitated into the sea with a loud detonation. Such a fragment is an iceberg The natives of Greenland in speaking of such an event say that the glacier has *calved* This last act of the operation of nature has frequently been observed by the Europeans settled on the western shores of Greenland, and by Captain Graah on

the eastern, though this gentleman was not so fortunate as to be an eye-witness of the formation of a large iceberg. He states, however, that he has seen many icebergs which had the semi-transparent and bluish colour, by which the ice of the glaciers is mostly distinguished But icebergs of such a colour are only met with near the shores of Greenland It appears that this colour soon undergoes a change, which probably is effected by the foggy atmosphere in which they are usually enveloped. Another circumstance which may be produced in favour of the opinion that the icebergs are only large fragments of glaciers, is—the localities in which they occur in great numbers Fields, floes, and other masses of sheet ice are floating about in great numbers in the sea which separates Greenland from Spitzbergen, but only a few icebergs are found there, and they are commonly of small size This is with reason ascribed to the small number of glaciers which are met with in the countries which surround the shores of this portion of the Arctic Ocean Only a few of them and these of small extent, are found in Spitzbergen and the northern part of the eastern coast of Greenland It also does not appear that Captain Parry, in his ever memorable attempt to reach the North Pole over ice met with icebergs among the large masses which surround the pole on the north of Spitzbergen On the other hand, icebergs are extremely numerous in the narrow sea which divides Iceland from Greenland, and especially along the shores of the last-named country There they may be frequently seen by hundreds and sometimes by thousands, lying in a line and forming a sort of barrier along the shore. They are hardly less frequent in Davis's Strait as far north as 68 of latitude and there too they are of very large size The localities just mentioned are at the same time the only ones where immense masses of glaciers line the shores of the sea, and where frequently large portions of them are seen projecting considerably over the waves.

Now it may be asked in what manner these immense icy masses, which originate on the shores of Greenland, find their way to the centre of the Northern Atlantic, which they can only arrive at by travelling a distance of

more than one thousand two hundred miles from the places of their origin? They are brought down by a powerful current, which, from the place of its origin, is called the Polar current. In tracing the course of this current, it will not only be evident why icebergs are met with so far to the south, but it will also be comprehended for what reason these icy masses are limited to certain parts of the ocean, and are never met with near the shores of Europe, nor along those of Nova Scotia, New Brunswick, and the United States. The Polar current appears to originate under the immense masses of ice which surround the Arctic Pole. Captain Parry, at least, found that these masses were continually moving to the south-west, and this circumstance rendered abortive all his efforts to reach the pole by travelling over the ice. Continuing in the south-western direction, the current meets with the eastern shores of Greenland, and runs along them, first south and afterwards south-west, until it enters the narrow sea which divides Iceland from Greenland. It runs with considerable force, and its width certainly exceeds a hundred miles. Thus it happens that most of the fields and floes, by which the sea between Greenland and Spitzbergen is always encumbered, are carried to this narrow sea, and that only single masses of no great extent are met with to the east of Iceland. To this current it must also be ascribed that the sea between Iceland, Norway, and Scotland, is free from ice all the year round, whilst that portion of the sea which lies to the south-west of Iceland is at times almost choked up with fields, floes, and icebergs. The icebergs are supplied by the coast of Greenland opposite Iceland. These icebergs, as well as the fields and other sheet-ice, would certainly be dispersed over a much greater extent of sea, were they not pressed towards the shores of Greenland by the current, which south of 65° of latitude *runs* along shore, but *sets* directly in shore. In this manner the Northern Atlantic is kept clear from large ice-fields and icebergs, but the eastern shores of Greenland are so beset by them, that the attempts which have been repeatedly made to approach this coast from the sea have always turned out

unsuccessful. When the Polar current arrives at Cape Farewell, the most southern point of Greenland, it turns round it, and runs northward into Davis's Strait. Proceeding close to the western shores of Greenland, it continues northward as far as Holsteinborg (67° N. lat.), where, from causes not yet ascertained, it suddenly turns west, and proceeds to Cape Walsingham, on the western side of Davis's Strait. From this point it runs southward, along the shores of the American continent to Labrador. By these changes in the direction of its course, the Polar current sweeps away all the icebergs which are formed on both sides of Greenland, and carries them to the Atlantic." What immense quantities of ice are brought down in this way from the eastern shores of Greenland may be inferred from the statement of Captain Graah, that it forms in summer a belt round Cape Farewell from a hundred and twenty to a hundred and sixty miles in width, in which the ice is so closely packed that no vessel can venture to enter. Along the coast of Labrador the current following the coast-line gradually changes its southern into a south-eastern course, and carries the icy masses along the north-eastern shores of Newfoundland, and across the Great Bank, to the centre of the Northern Atlantic, where it meets with and merges into the Gulf Stream.

The icebergs are commonly found in the centre of the Northern Atlantic south of 45° of latitude from May to July, and rarely at any other season of the year. In winter no ice is found here. This fact seems to be the reverse of what might be expected, and, therefore, this circumstance requires an explanation. This is found in the fact that the Polar current does not run all the year round, but is subject to a regular interruption. At Cape Farewell it ceases to run in the middle of October, and from that time up to the middle of January no perceptible current is observed in the vicinity of the cape. This extraordinary fact has only lately come to our knowledge, and as yet no satisfactory attempt has been made to account for it. It is, however, certain that between October and the middle of January the sea round the

cape is free from ice, and at that season it may be approached by vessels with safety. About the middle of January the current again begins to run, and it is closely followed by the appearance of icebergs and fields. Following the impulse of the current, these masses make the above-mentioned circuit round Davis's Strait. They employ, as it appears, about two months in making this way, as in the middle of March they are observed to arrive at the coast of Labrador, north of Newfoundland. In these parts a large portion of the sea continues to be covered with icy masses for about three months, from March to June. Later in the season, in July and August, only some streams, composed mostly of floes and drift ice, are met with in these seas. They are commonly of comparatively narrow width, from about five to ten miles. It is in this season that the vessels of the Hudson's Bay Company can venture to force their way through them. If they were to try at an earlier period of the year, they would be wrecked. When the ice arrives in March near the coasts of Newfoundland, it is peopled by numerous herds of seals. This circumstance the inhabitants of Newfoundland have lately begun to turn to account. From three to four hundred vessels are annually sent from different places of the island to the icy masses in pursuit of seals, and though this branch of industry is beset with many dangers, and carried on with an annual loss of life, it is preferred to the coast fishery on the Great Bank, because much more lucrative. This fishery closes when the quantity of ice begins to diminish, which commonly happens at the end of May. From these facts we may infer that the greatest number and the largest of the icy masses pass round Cape Farewell between the middle of January and the end of April, and that after that time the supply gradually diminishes, until it ceases in October.

This is the route the icy masses take every year in advancing to the centre of the Northern Atlantic. Those by which the brig 'Ann' of Poole was surrounded in 1821, and the large ice-field met in 1841 by the 'Great Western,' must have got there by another way. Pro-

bably they had only advanced to Cape Farewell or its neighbourhood when the current ceased, and were left there to drift about. But in what way the one got so far southward as to be found near the Great Bank in January, and the other even to 43° N lat. in April, we have no means of determining.

The dangers to which vessels are exposed in navigating the seas where these masses are floating, are various and numerous. In the seas south of 50°, where commonly only single icebergs and floes are met with, the dangers are not great, and may easily be avoided by attention. But in the seas surrounding Greenland, and extending on the east to Spitzbergen, which are annually visited by numerous whaling vessels, icy masses of every description are floating about in all directions in countless numbers; and as they move with different degrees of velocity, the vessels are frequently entangled and beset by them. It is, indeed, strange that a greater number of these vessels are not lost than is actually the case. Still the loss is sometimes very considerable. The Dutch have lost as many as seventy-three sail of ships among the ice in one year. In the season of 1684 fourteen of their ships were wrecked and eleven more remained beset during the winter. In 1835 several [illegible] vessels were lost, and [illegible] were beset there during the following winter.

Though the icebergs have a more terrible appearance, and strike the imagination more, they are less dangerous than the ice-fields. It is generally found that a strong current runs along the sides of an iceberg, and by this current a vessel approaching too near the berg is sometimes violently forced against the mass and staved. To another description of danger the whaling vessels are exposed by mooring to icebergs. This is frequently done for shelter. The situation of the icebergs in smooth water is very little affected by the wind, and under the strongest gale they are not perceptibly moved, but, on the contrary, have the appearance of advancing windward, because every other description of ice moves rapidly past them, on account of its finding less resistance from the water, and consequently drifting faster to

leeward in proportion as its depth beneath the surface is diminished From the iceberg's firmness it often affords a stable mooring to a ship in strong adverse winds, or when it is incommoded or rendered unmanageable by the accumulation of drift-ice around The fisher then moors under the lee of the iceberg, the loose ice soon forces past, the ship remains nearly stationary, and gets thus a clear sea But this operation is frequently attended with considerable danger. The icebergs are often very nicely poised If a large piece of ice breaks off from one side, the whole mass is suddenly and rapidly turned over, by which event vessels have often been staved, and sometimes wrecked, whilst boats have been upset even at a considerable distance by the vast waves produced by the sudden change of position of the iceberg Sometimes vessels moor to an iceberg when in want of water They obtain it from the deep pools which in the summer season are found on the depressed surface of some bergs, or from the streams running down their sides The water is brought to the vessel with the greatest ease and dispatch For this purpose casks are landed upon the lower icebergs, filled and rolled into the sea, but from the higher, the water is conveyed by means of a long tube of canvas or leather into casks placed in the boats at the side of the ice, or even upon the deck of the ship, but if, meanwhile, the iceberg should fall into pieces, the vessel is buried under its icy mooring.

The navigation among ice-fields and floes is beset with much greater dangers The fields frequently have a rotatory movement it appears to be produced by the different force with which the current acts on the different sides of such a large body of ice By this movement their outer borders acquire a velocity of several miles per hour A field thus in motion coming in contact with another at rest, or, as it at times happens, with one which has a contrary direction of movement, produces a dreadful shock. It is easy to comprehend that a body of more than ten thousand millions of tons in weight, meeting with resistance when in motion, produces effects

which it is scarcely possible to conceive The weaker field is crushed with an awful noise; sometimes the destruction is mutual. Pieces of huge dimensions and great weight are frequently piled upon the top, to the height of twenty or thirty feet while a proportionate quantity is depressed below. That a ship placed between the two fields would not escape destruction, is easily to be imagined. Numbers of whalers have been destroyed in this way. Some have been thrown upon the ice, some have had their hulls completely torn open or divided into two, and others have been overrun by the ice and buried beneath its heaped fragments.

"In the year 1804," says Captain Scoresby, in his 'Account of the Arctic Regions,' "I had an opportunity of witnessing the effects produced by the lesser masses in motion Passing between two fields of ice newly formed, about a foot in thickness, they were observed rapidly to approach each other, and before our ship could pass the strait, they met with a velocity of three or four miles per hour The one overlaid the other, and presently covered many acres of surface. The ship proving an obstacle to the course of the ice, it squeezed up on both sides, shaking her in a dreadful manner, and producing a loud grinding or lengthened acute tremulous noise, according as the degree of pressure was diminished or increased, until it had risen as high as the deck After about two hours the motion ceased, and soon afterwards the two sheets of ice receded from each other nearly as rapidly as they had before advanced The ship in this case did not receive any injury, but had the ice been only half a foot thicker, she might have been wrecked"

To give an idea of the complicated dangers to which the whalers are frequently exposed in these seas, we extract the following passage from the same author, 'Voyage to the Northern Whale Fishery' During a gale, attended by a heavy fall of snow, he had moored his vessel to a floe "About 6 P M," he says, "the snow became so thick that we could scarcely see a hundred yards distinctly, and the wind was, if possible, more furious.

Two small icebergs now appeared setting towards the ship, but as they were not of a magnitude sufficient to endanger us without auxiliary pressure, we quietly awaited their approach. The first, which was about thirty-six feet above the level of the sea, struck the ship on the [illegible]board quarter, and turned her broadside to the wind; it then slipped clear, without occasioning us any damage whatever. The second iceberg approached us with more alarming rapidity; but as we had not the power of getting clear of it, we were obliged to receive the shock upon whatever part of the ship it might chance to fall. It came in contact with the rudder, and slightly bruised one of its timbers, then grazing the ship's quarter and broadside, it passed forward to the bows, and being fortunately kept from close contact aloft by a tongue projecting from its base, it cleared all our boats. At this juncture, when the ship was so much involved with icebergs as to render casting off impracticable, had the state of the weather permitted it, two floes came in sight from different quarters. One of them appeared to be rapidly closing upon us from the west, and the other from the south, which, with the floe that we were moored to occupying the eastern quarter, almost completely locked us [illegible]. To secure ourselves as far as possible against the [illegible] which now appeared certain, we fastened by a hawser a large heavy piece of ice ahead of the ship where the floes threatened the first contact, with the view of subjecting the interposed mass to the pressure, and with the hope of being then defended from [illegible] of it. The first shock of the floes was sustained by this mass with full effect, and for some time afterwards all things seemed quiet and safe. Suddenly, however, the pressure was renewed, in consequence, it was supposed, of some new stoppage to the drift of the floes with tenfold violence. Our barrier was squeezed deeply into the [illegible], and prodigious blocks of ice were broken off and raised up by the pressure. While we contemplated their mighty effects with much anxiety, the berg which shortly before had passed the ship began a revolving and a retrograde motion, so quick as to overtake us before we

could get the ropes off to slack astern, and suddenly nipped the ship on the larboard beam and bow against the floe by which we rode. The force was irresistible: it thrust the ship completely upon a broad tongue (or shelf under water) of the floe, until she was fairly grounded, and continued to squeeze her rapidly up the inclined plane formed by the tongue, until the ice came in contact beneath the keel. This was the work of a few moments, and in ten minutes all was again at rest. When the pressure ceased, we found that the ship had risen six or eight feet forward, and about two feet abaft.

"The floe on the starboard side was about a mile in diameter and forty feet in thickness, having a regular wall-side of solid ice five feet in height above the sea; on the tongue of this the ship was grounded. The ice-berg on the larboard side was about twenty feet high, and was in contact with the railing of the bows, and with the gunwale and channel-bends amidship. This berg was connected with a body of floes to the westward, several leagues in breadth. The only clear space was directly astern, where a small interstice and vein of water was produced by the intervention of the bergs. Any human exertion for our extrication from such a situation was now in vain, the ship being firmly cradled upon the tongue of ice which sustained her weight. Every instant we were apprehensive of total destruction, but the extraordinary position of the ice beneath her was the means of her preservation. The force exerted upon the ship to place her in such a situation, must evidently have been very violent. Two or three sharp cracks were heard at the time the ship was lifted, and a piece of plank, which proved to be part of the false keel, was torn off and floated up by the bower, but no other serious injury was yet discovered. Our situation, however, was at this time as dangerous and painful as possible. Every moment threatened us with shipwreck, while the raging of the storm, the heavy bewildering fall of sleet and snow, and the circumstance of every man on board being wet to the skin, rendered the prospect of our having to

...fuge on the ice most distressing We remained ... state of anxiety and apprehension about two ... On the one hand, we feared the calamity of ...ck, on the other, in case of her preservation, ...ed forward to immense difficulties before the ship ...y grounded could be got afloat While I walked ...deck under a variety of conflicting feelings, produced ...the anticipation of probable events, I was suddenly ...used by another squeeze of the ice, indicated by the ...king of the ship and the motion of the berg, which seemed to mark the moment of destruction. But this renewed pressure, by a singular and striking Providence, was the means of our preservation The nip took the ship about the bows, where it was received on a part rendered prodigiously strong by its arched form and the thickness of the interior fortifications It acted like the propulsion of a round body squeezed between the fingers, driving the ship astern, and projecting her clear of all the ice fairly afloat with a velocity equal to that of her first launching!"

When we consider the immense size of some of the ice-fields, which sometimes cover an area of several hundred square miles, it seems hardly possible that such a body of ice could be destroyed by the natural effects of a warm climate, the action of the atmosphere, and the power of the waves, and that within the space of two or three months If these natural powers alone were acting, it is probable that the ice-fields would preserve for a much longer time their consistency, and that they would advance much farther to the south than they usually do. Their destruction, however, is much accelerated by the icebergs and by the swell of the sea The icebergs, being more compact masses, settle much deeper in the sea. Some of them have been found to reach fifty or sixty fathoms below its level, whilst the more heavy ice-fields hardly ever sink to a depth of more than twenty feet,—or at the utmost twenty-five. This difference greatly affects their respective motions, that of the ice-fields being much quicker, probably because the current runs with greater rapidity on the surface of the sea than at a

greater depth. When under such circumstances a field of considerable thickness meets in its way an iceberg, the field is commonly ripped up in all its length, and broken up into floes Still greater is the effect of the swell of the sea The fields are commonly surrounded by a border of drift-ice, interspersed with floes, and in this state the swell affects them but little, as these smaller masses break the swell, and prevent it from reaching the great mass. But when this border has been driven off or melted away the effect is astonishing A swell, which is so inconsiderable that it would hardly be observed in open water, frequently breaks up the largest fields, and converts them wholly into floes and drift-ice in the space of a few hours As both the icebergs and the swell of the sea operate so powerfully to the destruction of the ice-fields in their long way from Davis's Strait to the centre of the Atlantic, it cannot be a matter of surprise that an ice-field has never been found south of 45° N. lat, with the exception of that which, as mentioned before, was met with by the 'Great Western'

Icebergs are not affected by the swell. They rise and fall with a tremendous noise, but their size and form remain the same But when acted upon by the sun, or by a temperate atmosphere, they become hollow and fragile. Large pieces are then liable to be broken off, and fall into the sea with a terrible crash. When this takes place the iceberg loses its equilibrium, turning sometimes on one side, and being occasionally inverted. The sea is thereby put into commotion, fields of ice in the vicinity are broken up, the waves extend, and the noise is heard at the distance of several miles Sometimes the rolling motion of the berg not ceasing, other pieces are loosened and detached until the whole mass falls asunder like a wreck Few only of the icebergs, it appears are destroyed in the northern seas. A large number of them, at least, get as far as the Great Bank of Newfoundland, which is occasionally crowded with them But many smaller ones are dissolved with the heat of the more southern sea into which they advance, and the larger ones get aground on the banks, where

they remain stationary until their size has been so far diminished that they again get afloat, and then they are carried farther to the south by the current. But the number of floes which are found south of 43° N lat is comparatively but small, and those which get into the Gulf Stream are quickly dissolved by its warm water, and by the warm and moist air which is superincumbent on that current Therefore all the icebergs which are met with south of 42 N lat are all in a state of rapid decay, but they may be dangerous to vessels in the night-time, if the thermometer is not attended to. For it has always been observed that in approaching an iceberg in these seas the thermometer descends gradually fifteen or twenty degrees In the month of May it lowers from 60° or 62 to 45 and 40° When such a sudden and great change in the temperature of the air is observed, the navigator may be certain that his vessel is in the vicinity of an iceberg, and he will soon be aware how to avoid the danger of striking against it.

Section VI.—The Gulf Stream.

The surface of our globe is composed of land and water. By far the greater part is covered with water, as, according to a rough calculation, the seas extend over about three-fourths of it, the remaining fourth only being occupied by land. The water of the sea is salt, less so towards the poles, and more so towards the equator. This is, with some reason, considered as a wise arrangement of Providence, for if this enormous body of water were ever to fall into a state of stagnancy, it would, if consisting of sweet water, soon become putrid, the more so as it is well known that numerous and large quantities of lifeless vegetable and animal matter are found in the sea, which are in a continual state of decomposition. The noxious exhalations which in such a case would arise from this stagnant body of water would speedily infect the whole atmosphere, which would thus become the source of innumerable diseases for all living creatures. It is to be apprehended that the land would become uninhabitable for man and beast, and be converted into a desert. Though it cannot be denied that this effect is fully prevented from taking place by the saltness of the sea-water, it appears in this, as in many other cases, that nature is gifted with other means tending to produce the same effect. Even if the sea-water was sweet there could hardly be any reason for apprehending such noxious effects, when it is considered that perhaps no portion of the ocean is for any length of time in a stagnant state, and that nearly the whole of its surface is almost always in motion.

The movements to which the ocean is subject originate in different phenomena. Those which are produced by

the tides are less extensive than the others. By the tides the surface of the sea is indeed alternately raised by some feet, and let down again, but it can hardly be asserted that by this remarkable operation of nature any portion of the sea is forced from its situation and compelled to change its place, except where the sea borders on land, and even there this effect is circumscribed by comparatively narrow limits. The winds have a much greater power to displace the water of the surface of the sea. They propel the upper stratum in the form of waves, and wherever they continue to blow from the same quarter for any length of time with some force, the whole surface is found to be in motion to the leeward. This is especially observable in those parts of the ocean which are subject to perpetual or periodical winds. The whole surface of the oceanic regions which are swayed by the perpetual or trade winds moves without interruption to the westward, at the rate of about twelve miles every day. This movement is still greater in those parts of the sea where the monsoons and periodical winds prevail, because these winds blow in general with greater force than the trade-winds, but in these regions the motion of the sea changes, of course, with the change of the monsoons. In those parts of the ocean where the winds frequently change the quarter from which they blow, and as frequently, if not more frequently, increase or diminish in strength, the motion of the surface-stratum becomes as it were neutralized by these changes, and is rarely of such a description as to be perceptible. The motion of the surface-stratum of the sea caused by the pressure of the winds goes by the name of *drift*. It does not appear that this effect of the winds extends to a great depth under the surface. For, according to the most authentic accounts, the waves, during the greatest gales, do not exceed sixty feet in a perpendicular line in height, and as by experience it is known that the effects even of a heavy gale are not felt at a depth of more than twenty feet under the hollow of the wave, we may presume that the motion of the drift does never extend to a depth of a hundred feet under the crest of the waves.

There is, however, still another movement met with in certain parts of the ocean, which certainly involves a much larger body of water, and which apparently extends to the very bottom of the sea. It is known by the name of *current*, or *stream*. These currents are frequently compared with the larger rivers of the continent, but this comparison holds good only so far as both the currents and the rivers are volumes of water moving in a certain direction, but if the width and the depth of the former, and the immense body of moving water in them, are considered, it can hardly be said that there exists between them and the rivers any point of comparison. The direction of most of the currents is not dependent on winds, and they are found to run as frequently north and south as east and west. In running from south to north or from north to south, it happens that they bring the warm water of the intertropical seas to the higher latitudes, or the cold water from the vicinity of the poles to the regions near the equator. Therefore it is found that nearly all currents following these directions are distinguished from the surrounding seas by the temperature of their waters being either higher or lower than that of the seas contiguous to their course.

It is not more than about seventy years that these currents have attracted the attention of navigators, and that information has been collected respecting their direction, velocity, and extent, as well as respecting the temperature of their waters. Many of them are still imperfectly known, though it is obvious that an exact knowledge of them would be very desirable, as they affect, to a considerable extent, the navigation of the seas through which they run.

The best known of these currents is the *Gulf Stream*. This is a vast body of water running from the coasts of North America towards Europe, and bringing the warm water of the Gulf of Mexico to the central regions of the North Atlantic. This current has been more carefully examined, because it traverses that part of the Atlantic which is more navigated than any other part

of the ocean, being besides distinguished by its velocity, its great width, and the high degree of temperature of its waters

The Gulf Stream originates in the Gulf of Mexico, whence also its name is derived. It is properly the efflux of that sea Its upper course describes a large segment of a circle, and lies between Florida Reef and the peninsula of the same name on one side, and the island of Cuba, the Sal Key Bank, and the Bahama Banks on the other side With a northern course it reaches the open ocean near 28° N lat. It continues to move in the same direction, and at no great distance from the shores of the United States, until it arrives at Cape Hatteras, north of 35° N lat In this its upper course the body of water in motion occupies a space varying between thirty-six and seventy-five miles, and may in this respect be compared with the wider western part of the British Channel, or with that portion of it which is west of the Bill of Portland From Cape Hatteras the Gulf Stream runs eastward into the Atlantic, and gradually expands to two hundred miles and more in width It continues to flow in that direction until it reaches 40° W long, when it turns gradually south-east and south. In approaching the islands of Corvo and Flores, which are the most western of the Azores, its current becomes weak, and at the south-west of these islands it is lost, and the warm water of the stream is dispersed over the sea. This is commonly the place where the Gulf Stream terminates But there are instances on record of the warm water of the Gulf Stream sometimes advancing as far eastward as the western coast of Portugal and Spain. The space which the Gulf Stream traverses between its efflux from the Gulf of Mexico to the islands of Corvo and Flores exceeds three thousand miles When its water reaches the coast of Portugal and Spain it runs about a thousand miles more These outlines show that the Gulf Stream is a phenomenon of first-rate magnitude, which deserves a more detailed description

In its upper course, between the place where it issues from the Gulf of Mexico and that where it enters the

Atlantic, the Gulf Stream may in some respects be considered as a vast river. No other current of the globe, at least like this part of the Gulf Stream, runs between banks so well defined on either side. On one side these banks are formed by the Florida Reef and the peninsula of that name, and on the other by the island of Cuba, the Sal Key Bank, and the Great and Little Bahama Banks. These banks are not *banks of sounding*, a term applied to those parts of the sea whose bottom is within the reach of the common sounding-line, which is a hundred fathoms long. The Sal Key Bank and the Bahama Banks are *proper banks*. They rise not gradually, but suddenly, and from a very deep sea. The surface, near the edges of the banks, is but a few fathoms below the common level of the sea, and towards the interior many places are found which are only a few feet under water; some are quite dry at low tide. Besides, at many places along their edges these banks are beset with rocks even with the water's edge or above its level. It is obvious, from this description, that such banks must influence the current precisely as if it were running between banks of land. Accordingly we find that the Gulf Stream, contrary to the nature of other currents, is compelled by these banks to bend in the form of a large segment of a circle. Hemmed in on either side, its waters are not only prevented from spreading, but, as these banks draw closer together as the stream proceeds farther on, the great volume of water is gradually compressed into a much narrower space, by which its velocity is so increased, that before it reaches the Atlantic it has acquired a rapidity which is much superior to that of navigable rivers, and resembles that of a mountain stream.

The place where the waters issuing from the Gulf of Mexico are first clearly perceptible as a current, is found between the harbour of Bahia Honda on the island of Cuba, and the Tortugas Islands, near the meridian of 83° W. long. At this point the sea is about 80 miles wide, and the current runs rather slowly due east past the harbour of the Havannah to Matanzas and Punta de Ycacos. As in all this space the width of the water-way

is but little diminished, the current is not much increased in velocity But at Punta de Ycacos it meets the bank which extends along the northern coast of Cuba, which prevents it from proceeding in a due eastern direction. The stream therefore is compelled to run off to the north-east, where it encounters the Sal Key Bank Here it enters the Strait of Florida, which at this place is only forty-eight miles wide. The waters which above Punta de Ycacos flowed in a channel eighty miles wide, are at the entrance of the Strait of Florida pressed into a strait not much more than half as wide Their velocity consequently is so increased, that in summer they run commonly at the rate of forty-eight miles every day Having passed along the northern edge of the Sal Key Bank in a north-eastern direction, the current rushes with great force against the western edge of the Great Bahama Bank, and is repulsed The stream is thus compelled to flow along the edge of this bank northward In this direction it enters the Narrows of the Strait of Florida, where the sea area between Cape Florida and the Bemini Islands is reduced to a width of forty-four miles But some rocks and reefs which are found on either side of the strait in these parts still further reduce the water-way to thirty-six miles The immense volume of water which higher up ran through a channel of eighty miles, is in the Narrows compressed into a space of thirty-six miles, and its velocity is consequently greatly increased Within the Narrows of the Strait of Florida the Gulf Stream runs in summer from eighty to ninety-six miles per day, or from three and a-half to four miles per hour Sometimes it runs even a hundred and twenty miles per day, or five miles per hour This is the greatest degree of velocity the Gulf Stream attains, and it is hardly practicable for sailing vessels to stem the current if not aided by a favourable gale In winter the velocity is commonly reduced to two or two miles and a-half per hour, and as at that period northern winds prevail, it may be ascended. The northern portion of the Strait of Florida, [illegible] which is north of 26° N lat, gradually increases in width, and where it terminates, at 28° N. lat, it is more than

fifty miles wide. Though the waters find here a greater space to expand, their velocity is not much decreased For at the Maternillo Reef (27° 40′) they continue to run in summer at the rate of eighty miles per day That portion of the Gulf Stream which hitherto has been noticed is about four hundred miles long It runs from Bahia Hondo one hundred miles to Punta de Yeacos, and thence sixty to the Sal Key Bank In the Strait of Florida it flows ninety miles before it reaches the Bemini Islands, and then in the Narrows thirty miles Below the Narrows the strait is still a hundred and twenty miles long

As the velocity of the Gulf Stream above Punta de Yeacos is not great, the Gulf of Mexico may be compared to a vessel filled up to the brim, from which the waters flow off slowly at the only place where it can escape. If, in running eastward, the body of moving water was not compressed by the narrowing of its banks, and had met with an outlet as wide as the channel in which it flows farther upward, it would have run off to the Atlantic with a velocity but slightly increased by the pressure of the column of water which urges it on from behind As it is, the pressure of this column is continually increasing by the decrease of the width of the strait into which it is forced When the Gulf Stream arrives at the Narrows, the column of water which presses on it from behind is two hundred and fifty miles long, and the channel into which it passes is reduced to much less than its former width These circumstances taken together account for the great degree of velocity with which the waters pass through the Narrows, and continue to flow until they leave the Strait of Florida In this part the velocity of the stream may be compared to the *bore* which is found in the Ganges and the Bristol Channel, except that in the Narrows the rush of the waters is continual, whilst at the two places just mentioned the bore is only observed twice in twenty-five hours, being produced by the tide-wave suddenly rushing into a channel which grows continually narrower.

At 28° N. lat. the Gulf Stream enters the Atlantic It follows, of course, the impulse its waters have received in the Strait of Florida, and runs northward. On the east of the stream lies the wide expanse of the Atlantic, and on the west the shores of the United States. As these shores recede from the current, trending to the west of north, the Gulf Stream is now free from the obstacles which hemmed in its course farther upward, and begins gradually to expand Opposite to the town of Charlestown it is more than sixty miles wide Near this place the banks of soundings skirting the American coast prevent the stream from continuing northward, and deflect it to the north-east In this direction it continues to Cape Hatteras Opposite this cape the width of the current has increased to seventy-five miles From its outfall into the Atlantic to Cape Hatteras, the Gulf Stream has traversed a space of five hundred miles. Its velocity has decreased, but less than one would expect, when it is considered that its width has increased to more than double the extent it has at the Narrows of the Strait of Florida At Cape Hatteras it still runs commonly at the rate of three miles per hour in summer, and sometimes even more It must, however, be observed, that this degree of velocity is only found in the middle of the stream, and that it runs more slowly towards its borders. This observation applies to the whole course of the Gulf Stream in the Atlantic

The Gulf Stream may be said to leave the coast of America opposite Cape Hatteras Its farther course lies across the Atlantic. The waters moving along the outer or eastern border of the stream turn entirely to the east at 36° N. lat , but those constituting the inner or western border continue to flow to the north-east until they approach 38° N lat., when they also take an easterly direction. They are compelled to this change in their direction by the banks of soundings which extend along the shores of New York and New England, and are known by the names of Nantucket and St George's Banks. These banks extend far into the Atlantic, and

the Gulf Stream runs at no great distance from their southern edges At the meridian of 72° W. long the whole immense body of water is moving eastward Shortly after it has passed Cape Hatteras, the width of the stream is not less than a hundred miles, and it increases continually in proceeding eastward, so that at 63° W long, where it is frequently crossed by vessels sailing from the Bermudas to Nova Scotia, it is about one hundred and fifty miles wide It is there about six hundred miles from Cape Hatteras It is justly considered as a matter of surprise, that by this long run, and by its expanding to double its previous width the velocity of the current is so little affected, for at 63° W. long. it is still found to run from two to three miles per hour in summer, in the middle of the stream

Near 63 W long another change is observed St. George's Bank terminates near 65° W long The Gulf Stream having still preserved an inclination to set to the northward, advances gradually to between 41° and 42° N. lat By this change its width is increased, and it soon attains its greatest breadth east of 60° W long In these parts of the Atlantic it hardly anywhere falls short of two hundred miles in width, occupying almost entirely the whole sea between 37° and 41° N lat But though its northern border has advanced farther north, the great body of water flows directly eastward In these parts the velocity of the steam is greatly reduced, for in approaching 45° W long, or after a run of nine hundred miles more, it is never found to exceed one mile and a half per hour, and sometimes it is reduced to one mile

Near 45° W long the Gulf Stream is joined by a great body of cold water, which is brought down from the seas surrounding Greenland and Labrador by the Polar current It is this current which, in the months of May, June, and July, brings, from the Arctic regions, a great number of icebergs to the centre of the Atlantic, where sometimes vessels are destroyed by them, of which an instance occurred as late as last year (1844) These enormous icy masses, however, are speedily dissolved as

soon as they enter the warm water of the Gulf Stream, and, therefore, an iceberg has never been seen to the south of 40° N lat

It appears that its junction with the Polar current affects the direction of the Gulf Stream; for near 40° W. long the current decidedly sets to the south-east, and gradually it turns to the south Its velocity abates by degrees, until the current becomes imperceptible to the west and south of the islands of Corvo and Flores, near 31° W long and 36° N lat Here it may be said that the Gulf Stream terminates North of the above-named islands, it yet runs, however, from ten to twelve miles per day

It is very difficult to estimate the width of the Gulf Stream near its termination, for the waters which move along its southern border do not extend so far east as the northern current, but terminate near 42° W. long Both currents therefore, cease to flow near 36° N lat, but at a distance of more than five hundred miles from one another The space between them must be considered as the mouth of the Gulf Stream

In the mouth of the Gulf Stream thus defined, a phenomenon occurs of a peculiar nature, but which impresses on this great oceanic river a certain degree of resemblance with our large continental streams * It is found that the Gulf Stream has formed an island within its mouth It is a well-known fact that nearly all rivers bring down from the countries which they drain large quantities of earthy matter, which they deposit on approaching their mouths, and thus alluvial islands are gradually formed, larger or smaller, mostly in proportion to the volume of water the river contains. Sometimes only one island is formed, but commonly several islands, which are divided from each other by channels A similar phenomenon is observed also in the mouth of the Gulf Stream The current indeed does not bring down earthy matter, but in every part of its course single plants of sea-weed, or *fucus natans*, is found swimming This sea-weed is floated by the current to its mouth, where it may be said to form a number of islands In no

part of the ocean is the sea-weed found in such masses as in the mouth of the Gulf Stream, where it forms a bank of great extent The resemblance between the fucus bank and the deposits of the rivers extends even to its form. The alluvial islands in rivers are much narrower at their upper than at their lower ends, they gradually get wider towards the place where the rivers reach the sea The same form is observed in the fucus bank A few patches of sea-weed only are met with near 40° N lat, and even farther north They grow more numerous and larger in proceeding southward, and between 36° and 30° N lat, and 38° and 42° W long, the quantity of this weed is really astonishing It covers like a mantle the surface of the sea for many miles, but usually lies in lines which vary from a few yards to three hundred or four hundred fathoms in width The weed is frequently found in large patches of irregular shape, but generally of a circular form. These fucus islands extend far beyond the mouth of the Gulf Stream, and may be compared with the deltas of the Mississippi, the Nile, and the river of Cambojah, which extend far into the sea Patches of gulf-weed occur at a considerable distance south of 30° N lat, as far as 25° and even farther, but in these parts the patches lie at greater distances from one another The existence of these banks in such a southern latitude has led to the supposition that the current of the Gulf Stream extends to that parallel, though it has ceased to be perceptible almost ten degrees farther northward

The width which we have assigned to the Gulf Stream in different parts of its course, refers to the stream itself, it indicates the space in the Atlantic where a current has actually been met with But the warm water brought down by the stream spreads over a much larger space As far as the current runs along the coast of America it does not appear that warm water is found to any considerable distance on the sides of the Gulf Stream, but where it traverses the Atlantic it extends to a very great distance from the current In these parts the Gulf Stream resembles a large river running through a vast plain which is but little elevated above the level

of its surface, and which is therefore overflowed every time the surface of the river is raised to a somewhat higher level. In the same manner the Gulf Stream diffuses large volumes of warm water along both its borders. How extensive these overflowings are may be inferred from the fact that the width of the Gulf Stream along the line of navigation between the Bermudas and Nova Scotia, at one time was found to be only one hundred and fifty miles, whilst at another time the warm water covered a breadth of three hundred and twenty miles, the overflowing on both sides, therefore, spread over a space of one hundred and seventy miles in width. Farther to the east the warm water, inclusive of the stream itself, occupies a width varying from three hundred to four hundred miles, though the current itself perhaps, nowhere exceeds two hundred miles. Hence it happens sometimes that warm water is found as far north as 45° N. lat., covering the southern extremity of the Great Bank of Newfoundland.

Thus we find that the Gulf Stream and its widely extended overflowings form a body of warm water of great extent in the middle of the North Atlantic. This expanse of warm water extends from 75° to 30° W. long. in length, occupying a space in width at the east end from the 33rd or 34th to the 45th degree of latitude, and being at the west end from 160 to 170 miles wide. Its length therefore, from west to east, exceeds 2000 miles, and its breadth, from north to south, may be taken at a mean to be more than 360 miles. This gives an area of 720,000 square miles and is equal to four times the extent of France, and larger than the Mediterranean Sea. Sometimes its area is yet greater, and the warm water is found to extend to the very shores of Europe. Dr. Franklin found warm water, in November, 1776, in the sea surrounding Cape Ortugal in Spain, and Captain Sabine, in January, 1822, in the sea between Portugal and the Azores. These facts have led to the supposition that at certain times the supply of warm water brought by the Gulf Stream from the Columbian Sea is more than commonly abundant, and that then the force of the

stream is increased to such a degree that the current does not cease at the Azores, but is continued to the shores of the Old Continent.

If the immense area which the warm water of the Gulf Stream covers is a matter of surprise, its high temperature is not less so, especially as it is found to preserve a great part of this temperature to its very termination. It is not difficult to account for the high temperature of the Gulf Stream at its source, as no part of the ocean has so high a temperature as the waters of the Gulf of Mexico. It is found in summer to vary between 86° and 88°, whilst in the open Atlantic, under the same parallel, it is only 78°. Under the equator the temperature of the sea varies in summer between 82° and 84°. The waters of the Gulf of Mexico are therefore four degrees warmer than those under the line. The Gulf of Mexico resembles a vast *cauldron*, employed in heating water for distribution over the central parts of the Atlantic.

It is calculated that the stream in twelve days runs from the Sea of Mexico to Cape Hatteras, a distance exceeding nine hundred miles, and it has been ascertained that the temperature of the water at the last mentioned place is still 83°. This is an astonishing fact, considering that the water has passed through eleven degrees of latitude (from 24° to 35°), and that in this space the oceanic water has diminished six degrees of temperature (from 78° to 72°). How can such an extraordinary fact be accounted for? By what circumstance is the Gulf Stream enabled to prevent its waters from becoming colder in the same proportion as happens with the water of the ocean when it passes through eleven degrees of latitude? There appears to be no other manner of explaining this fact than by supposing that the body of warm water is so immense that it is but slightly affected by the increasing cold of the atmosphere. If only the superficial stratum consisted of warm water, it would soon cool down to the common temperature. We must therefore assume that the warm water reaches to the very bottom of the sea. As none have yet suc-

ceeded in ascertaining the depth of the sea at any place within the Gulf Stream, we may assume that the current has scooped out a very deep bed in the bottom of the ocean This assumption can hardly be questioned when we consider its extraordinary velocity between Sal Key Bank and Cape Hatteras

After leaving the coasts of America the Gulf Stream expands to a greater width, and its velocity is decreased, as before stated Its temperature also decreases, but not in proportion to the decrease of velocity or the widening of the current For after having run in twelve days from Cape Hatteras to 63° W long, about six hundred miles, and increased in latitude about four degrees, the temperature has only decreased two degrees, being still 81° or nearly equal to that of the sea near the equator If this part of its course is added to that before noticed, we find that the water of the Gulf Stream passing in twenty-four days through fifteen degrees of latitude, loses only five degrees of heat In the remainder of its course the decrease of temperature is more rapid. From 63° W long to Corvo and Flores it runs fifteen hundred miles, and passes through this space, according to a calculation which deserves confidence in fifty-two days. The temperature of its waters is then reduced from 81° to 72°, but even at its termination it is by six degrees higher than that of the contiguous seas

By comparing the temperature of the Gulf Stream with that of the Atlantic under the same parallel, we find that in the first half of its course, or up to the place where it passes 63° W. long. the water of the Gulf Stream is 12½° warmer than that of the ocean, but in the second half, not more at a mean than 7½°

Such an immense body of water, heated to such a degree above the temperature of the contiguous seas, and consequently also above that of the atmosphere, must of course greatly affect the air incumbent on it The difference between the temperature of the air and the water must cause a continual evaporation, in order to affect an equilibrium between the two elements, and the vapours thus generated must render the air warm and damp.

This is just one of the peculiarities by which this region of the Atlantic is distinguished, and it is especially observed in winter. The air at this season is described as being extremely heavy, warm, and damp, to such a degree even as to affect the chronometers, which become irregular. This temperature of the air raises the thermometer to summer heat, sometimes to 80°, whilst it remains near the freezing point beyond the borders both south and north of the Gulf Stream. Every gale, or even a common breeze, must carry this hot air beyond the limits of the warm water, and thus affect the adjacent seas and countries. Few regions in the world perhaps are subject to such sudden and great changes in its temperature as the middle states of the American Union. These changes are produced by the winds suddenly shifting from north or north-west to south and south-east, or *vice versa*. It may be assumed with much reason that one of the principal causes of these changes is to be found in the warm and moist air incumbent on the warm water of the Gulf Stream.

To the same cause another peculiarity must be ascribed, by which this aquatic region is distinguished—the frequency of gales. There is perhaps no other part of the ocean where the gales are so common as in the seas which lie on both sides of the borders of the warm water. It is therefore supposed that they owe their origin to the warm air coming into contact with the much colder air incumbent on the seas contiguous to the stream. As the two bodies of air differ by many degrees of the thermometer in their temperature, the equilibrium between them cannot be established but by a very violent disruption, and this gives rise to the storms. These gales, and in general every wind encountered in or near the Gulf Stream, have a peculiar character. They do not blow with a continual and regular strength, but in sudden puffs, following one another in quick succession. It may perhaps not be out of place to observe here, that this is also partly the character of our winds blowing from all points between south and west, whilst those from other quarters commonly blow with a regular force, and in-

crease or decrease gradually in strength This difference in the character of our winds has greatly puzzled all those who have investigated this matter May it not be that the effects produced by the sudden changes in the atmosphere, in consequence of the evaporation of the warm water of the Gulf Stream, extend to our shores? and may not also the higher degree of warmth by which south-western winds are characterized in winter, and which doubtless render our winters less constant but also less rigorous than those experienced in the interior of the European continent, be likewise ascribed to the same cause?

These gales are much dreaded by the seamen, but still more so is the sea where they prevail Even during the prevalence of common breezes, when they oppose the current, the sea is always heavy and broken, so as to occasion a ship to labour much under any trim of sail whatever But whenever a gale blows against the current, the sea is agitated to such a degree, and its high waves cross one another so rapidly, that the seamen cannot find words strong enough to express its fury

These observations prove that the navigation of the North Atlantic is materially affected by the Gulf Stream When the existence, extent, and velocity of this extraordinary current had been fully ascertained, it was considered as a discovery which would greatly benefit the return voyages from the West Indies Accordingly, most of the vessels which were bound to Europe, on leaving the Caribbean Sea and the Gulf of Mexico, followed the course of the Gulf Stream in its whole extent, along the American coast and across the Atlantic. It was found that by following this track vessels saved about five days' sailing at a mean, which was a considerable advantage in a voyage not occupying on an average more than forty days But, at the same time, it was ascertained that the wear and tear of the vessels, by being exposed to almost continual gales and a very heavy sea, was so great that it more than counterbalanced the saving of time For this reason the track at present is hardly

ever followed by merchant vessels. They take advantage of the Gulf Stream for the purpose only of getting out of the region of the trade-winds Therefore they follow the stream only through the Strait of Florida, and as soon as they have passed Matern[illegible]lo Bank they turn to the east As the southern border of the Region of Storms lies between 33° and 34° N lat., the vessels continue their eastern course south of this parallel, passing south of the Bermudas, and not till they find that they are about 15° east of these islands do they steer direct for Corvo. By keeping this track they avoid at least two-thirds of the Region of Storms. Vessels sailing from the southern and middle states of the American Union to Europe follow the same track. Those which sail from New York to Europe keep to the north of the Gulf Stream until they reach 55° W long, where they enter its most northern portion, but they leave it again near 45° This is the most dangerous part of the voyage, as they may here expect gales, and in May, June, and July the icebergs from the Arctic Sea Vessels sailing from Europe to North America keep either to the north or to the south of the Gulf Stream, according to the seasons

The human mind is so constituted that it feels an irresistible desire to explain every phenomenon of nature with which it becomes acquainted. As the Gulf Stream is one of the greatest and most singular phenomena, it is, of course, asked whether its origin can be accounted for in accordance with the known laws of nature Several attempts have been made, but the only satisfactory explanation is that which ascribes its origin to the great accumulation of water along the South American coast, partly the effect of the trade-winds, and partly of the peculiar formation of that coast

This explanation rests on the well-ascertained fact, that a high wind, by the pressure it exercises on the surface of a body of water, is able to raise the water higher on the lee-side than it is to windward Instances of this kind are frequent. An attentive observer will easily

ascertain in a common pond, when a high wind blows in its longitudinal direction, that that extremity of it which is to the leeward has its level raised by pressure of the wind to an inch and more above its common level. The same phenomenon is still more distinctly perceptible in a canal. Let us take a section of a canal three miles in length, and having at each extremity a lock. If a high wind blows for a few hours in the longitudinal direction of the canal, the water accumulates at the lock to leeward from a foot to eighteen inches higher than at the other end. The same effect is frequently seen in inlets and narrow seas, especially when they are wider to windward than to leeward. It is a well-known fact, that heavy western and south-western winds, when they continue to blow for some days, drive large volumes of water into the British Channel, which accumulate in the Straits of Dover, and raise the level of the strait, it is stated, by ten feet. When this accumulation takes place during the fall and change of the moon, the spring-tides coming from the North Sea are prevented by the accumulated water in the strait from flowing off in the usual way, and it is then that the tides in the Thames rise above their common level, and the lower parts of London are inundated. A very extraordinary instance of the power of the wind to raise the level of a body of water by pressure, has been seen by the author in a river falling into the Baltic. A wind blowing a hurricane, in six hours raised the level of the river, three miles above its mouth, more than thirty feet above its common height, and laid an immense tract of low ground under water. It must be kept in mind, that in all these instances the surface of the water between the lowest and highest point is a slightly inclined plain, which rises towards the leeward, and grows lower towards the point from which the wind blows.

The Gulf Stream is the effect of a similar operation of nature, and the ultimate cause of it are the trade-winds. The winds never blow a gale, but only a moderate breeze. The idea of their force can be conceived when

it is remembered that these winds propel a common sailing vessel at the rate of from five to six miles per hour They blow, however, without interruption, and increase or decrease only occasionally a little in strength. That such a wind is able to move by its pressure the surface-stratum of the sea to the leeward is evident from the fact that south of 28° N lat, where the trade-winds are met with, the whole surface of the sea is moving westward at the mean rate of twelve miles per day. This being a fact which does not admit of any doubt, it will easily be comprehended that an accumulation of water must take place along the lee-shore, that is, along the eastern coasts of America. If these coasts ran in a straight line north and south, the accumulated waters would run off in a current along the shores, but this current would certainly not be of such a size or velocity as to be compared with the Gulf Stream The peculiar conformation of the eastern coasts of America between 28° N lat and the equator is the cause that along its shores a greater accumulation of water is effected than at any other place of the widely extended ocean

By a straight line drawn on a chart of the Northern Atlantic, from Cape Race in Newfoundland, to the mouth of the Amazonas River in South America, this sea is divided into two parts The eastern portion communicates at both extremities with a sea as wide, or nearly as wide, as itself But the western part is an immense bay, which almost continually grows narrower in proceeding farther west, and which terminates in the Gulf of Mexico This gulf constitutes the innermost recess of the great Atlantic Bay All the water put in motion in the North Atlantic by the trade-winds, is driven into this bay, and accumulates within its innermost recesses In the southern part of the sea, between the equator and 10° N lat, the drift current of the trade-winds accumulates the water along the coast of Guiana, on which the stream sets obliquely, and is thus compelled to run off along the shores in a north-western direction. This water forms a current, which is known

by the name of the Guiana current, and which carries its water to the Caribbean Sea, by the straits found between the South American continent and the island of Dominica. In all these straits the water sets westward into the Caribbean Sea at a rate of about twenty-one miles per day. Farther to the north, between Dominica and the island of Cuba, all the water accumulated by the trade-winds enters the Caribbean Sea, running at the rate of a common drift current, or about twelve miles per day, and passing through the numerous straits between the two last-mentioned islands It is certainly a remarkable fact, which must not be lost sight of in explaining the origin of the Gulf Stream, that through all the avenues leading to the Caribbean Sea the water of the Atlantic enters as a current, and that in no one of these numerous straits is it ever found to return eastward into the ocean The whole surface of the Caribbean Sea is likewise moving westward, and being repulsed by the coasts of Central America, it runs off to the northwest and enters the Gulf of Mexico by the Strait of Yucatan Thus we find that the Caribbean Sea, and ultimately the Gulf of Mexico, is the receptacle of all the waters accumulated by the trade-winds in the North Atlantic

All these facts tend to impress us with the idea that the waters in the Caribbean Sea and Gulf of Mexico must have a level considerably elevated above that of the Atlantic between the Canaries and the Cape Verde Islands, and that this difference is produced by the continual pressure exercised by the trade-winds on the surface of the North Atlantic. But we have no means to determine this difference by calculations We can only judge of it by the velocity with which the Gulf Stream carries off the superabundance of waters through the Strait of Florida If the velocity of the stream was the effect of this difference alone, we should be justified in supposing that it must be very considerable, but it appears that in the Gulf Stream, as in rivers, the velocity is the effect produced partly by the fall, and partly by the column of waters which press from behind.

To render the manner in which the Gulf Stream is formed still more comprehensible to the reader, it may be supposed that the trade-winds are strong enough to raise the surface-stratum of the sea an inch in each mile, and to keep it always at that level. Continuing at this rate through the whole extent of the Atlantic, the level of the ocean in the straits leading to the Caribbean Sea would be more than 200 feet above its level near the Cape Verde Islands, as the distance between them falls not much short of 2500 miles. The same pressure operating on the surface of the Caribbean Sea, which is about 1500 miles long, would raise the level by 125 feet more. The result of such a calculation would be that the Gulf of Mexico is elevated by 325 feet above the North Atlantic near the coast of Africa, and this elevation may perhaps appear sufficient to explain the velocity of the Gulf Stream, when the immense column of water is taken into account which presses on it from behind.

It appears that the water which is put in motion by the trade-winds acquires in its passage from the coast of Africa to that of America a much higher degree of temperature. At a distance of about four hundred miles from the coast of Senegambia its temperature in summer is about 74°, but in the Caribbean Sea it is 82°. This temperature is still raised in the Gulf of Mexico, where a great portion of it certainly remains for a considerable time, on account of the peculiar form of that sea, and because the two channels, that by which it receives its supply of water, and the other, by which it discharges its superabundance, are found at no great distance from one another. The gulf resembles in its form a large segment of a circle, equal to more than three-fourths of the whole. The water, entering into this sea by the Strait of Yucatan, takes two different directions. One portion of it runs directly north-east to the place where the Gulf Stream begins, while another very large portion is carried to the west. This last body of water, running along the coast of Mexico, makes a wide circuit, until,

having arrived opposite the mouth of the Mississippi, it turns south-east, and in approaching the Tortugas Islands unites with that body which runs hither from the Straits of Yucatan. As the currents within the Gulf of Mexico are very moderate, it may be easily comprehended that the temperature of the waters during their prolonged stay there is raised from 82° to 86°, or even 88°, as it has been found at many places

Section VII.—The Samoom.

In countries which border on sandy deserts a very hot wind, which powerfully affects the animal creation, is generally experienced whenever the wind blows thence In Syria, and at Mekka in Arabia such a wind blows from the east, in Egypt from the south-south-west and south-west, and at Surat, in Hindustan, from the north, in Senegambia and in Guinea from the north-east This wind, of course, bears different names in the different countries In Egypt it is called *khamsin*, and along the western shores of Africa *harmattan* The Arabs call it *samoom*, which signifies a *burning* or *poisonous* wind, and this term has been adopted in the European languages In Turkey it bears the name of *samieli* Many persons think that all these terms are used to indicate the same kind of hot wind, but, in reality, the winds which are designated by them differ greatly in their qualities Thus, for instance, the harmattan, so far from being poisonous, and causing the death of travellers, is considered by all Europeans settled on the western coast of Africa as a healthy wind, which is also proved by the effects it produces It blows from the side of the great desert of the Sahara, and, passing over its sandy plains, it acquires an extraordinary degree of heat and dryness, so that even the best seasoned timber shrinks considerably, and all wooden furniture falls to pieces It produces, also, chaps in the lips, and afflicts many of the natives with sore eyes But, as it immediately succeeds the rainy season, the changes produced in the atmosphere by the harmattan are greatly desired. During the long rains the air is so loaded with moisture, that the inhabitants of Senegambia may be said to live

in a sort of vapour-bath, and everything which is not close to the fire becomes damp and mouldy. The effect of this excess of moisture is extremely hurtful to the health of the inhabitants, especially the Europeans, who are attacked at this period by putrid and malignant fevers, of which a great number die. But as soon as the harmattan begins to blow, this state of things is changed, and persons who have fallen ill during the rains recover their health in a short time.

The samoom, however, of Syria and Arabia is of a very different description. Its effects on the human frame are extremely deleterious, and many of the Mohammedans who go on pilgrimage from Turkey and Persia to Mekka are killed by it, as their road lies through countries extending along the Syrian Desert, where the wind originating in that sandy plain appears to possess more noxious qualities than any other. It always makes its appearance during strong south-western winds, but only between the middle of June and the 21st of September. This wind blows only in short gusts, which are of unequal duration, but even the shortest continue longer than it is possible for any man to hold his breath. The gusts are burning hot, but the intervals are much cooler. The difference of temperature between the gusts and the intervals is said to amount sometimes to ten degrees of Fahrenheit. It is easy to conceive that the human body, exposed repeatedly and suddenly to such a difference of heat, must be greatly affected. During the hot gusts the thermometer in September rises to 78°, whilst on those days on which the samoom is not felt it varies between 53°8 and 58°8. Some travellers assert that when the samoom blows, the atmosphere takes a yellowish hue, frequently passing into the colour of lead, and that the sun appears dark-red whenever it blows with force. It is attended with a putrid and sulphureous smell, and the air appears to be thick and heavy, so as to excite the feeling of suffocation. It occasions a profuse perspiration, increased still further by the oppression felt on the chest, and by the difficulty of respiration. The perspiration itself is

thicker and more adhesive than in common cases. It is even thought that the wind deposits a greasy fluid on the skin. If a person, for experiment's sake, inhales the wind, his palate and throat become instantly dried up. The same effects are experienced from inhaling it by the nose, but not so suddenly. To prevent this effect, and to render respiration more easy, the Arabs cover their faces with the *kafieh*, a handkerchief which they wear on their heads. In passing through the texture of this fabric the wind loses a part of its effect and of its noxious qualities. A certain degree of moisture is also imparted to the air between the kafieh and the mouth by the breath itself, which greatly facilitates respiration, and the burning air is prevented from penetrating suddenly into the mouth and lungs. The Arabs have also, generally, adopted the practice of enveloping their whole body and even the head in a large cloak when they lay down to sleep, whatever may be the degree of heat they have to endure. It is supposed that the samoom renders the blood less consistent, and that this produces a quicker circulation, the effects of which are felt in a rapidly increasing debility. It is certain that this wind, when it does not kill, always produces a great degree of exhaustion. Many persons, however, who are considered as being in a dying state, recover their health on discharging blood from the urinary vessels. As a peculiar fact, it is stated that the bodies of those who have been killed by the samoom undergo in a few days, and even hours, a peculiar kind of dissolution. A very small force is able to remove all the bones from their sockets. This is the statement of the Arabs, who consider such a corpse as contagious as the plague. During the wind, respiration is much relieved by strong vinegar being applied to the nose, and this is also said to diminish its noxious effects. Sometimes the samoom lasts for three days and three nights together, but not commonly. There are, however, instances in which it has continued to blow for seven days. Sometimes it is not experienced for a period of ten, and even fourteen, days; but the Arabs think that it has only changed its place, and is

blowing in another part of the country. Formerly it was asserted that the hurtful effects of the wind could be avoided by a person throwing himself on the ground with the mouth downward, but modern writers say that the Arabs disapprove of such a proceeding, and perhaps justly, if it is true that the hot air by which the wind is attended is heavier than the atmosphere.

Section VIII.—Trade-Winds.

The seas by which our island is surrounded are under the influence of winds which frequently change their direction. They pass from one quarter of the compass to the other, and it is not a rare occurrence to find within three days, or even a shorter period, as many winds pass over our heads from opposite directions. It happens, indeed, that the wind sometimes blows continuously from one quarter for several days, or even weeks, but seldom oftener than once or twice a-year. It is also a well-known fact that at times the winds blow from different quarters at two places not very distant from one another, at the same time. Such being the case, it is evident that, except in very few and particular cases, nobody is able to foretell, with any degree of certainty, what wind we shall have to-morrow. But our winds do not only vary in direction—they vary still more in force. To-day a gale may blow, which occasions great havoc amongst our shipping, and strews the shores with fragments of vessels wrecked on rocks or lost at sea, and to-morrow it may lull into a calm which keeps the impatient navigator—returning to his country, and desirous to see his family and friends—nailed, as it were, to the spot. All degrees of force—between a storm blowing with a force bordering on that of a hurricane, and the most perfect dead calm—may be experienced in the short period of twenty-four hours, and even in less time. This state of wind and weather is not peculiar to the sea contiguous to Great Britain. It extends on all sides to a great distance. Navigating the seas which lie to the east or west of our island, no change in this respect is observable even in their most remote recesses, and

when we advance to the north, we find the winds always changing their direction and force, until our course is stopped by the icy masses which surround the Arctic Pole, and we have arrived at the utmost border of the known portion of the globe. But when we sail towards the equator, we arrive, after some time has elapsed, at regions where the wind always blows from the same quarter, or nearly so, and where its force is subject to very slight variations We are then in the region of the trade-winds Before we arrive at this region, however, we must pass through twenty degrees of latitude; and, after having made a voyage of about 1200 miles, we get to places where nature is subjected, in this respect as in many others, to a much more uniform and regular law than in our country

The trade-winds are met with, as we approach the northern tropic, at a distance varying between four and eight degrees The term *trade-winds* is of a doubtful origin and signification Some think that it has been applied to these winds on account of their constancy, *trade* originally signifying a common *course* or *track*, the *course treaded*, and Hakluyt has the phrase, "the wind blowing trade," i e a regular course. Others think that it has been introduced by our seamen, because they considered these winds more favourable to the promoting of trade and commerce than any other wind they were acquainted with Those who found the advantage of the perpetual winds, might entertain a certain degree of joy at finding that their toils were diminished and their voyages shortened How different were the feelings of those who first experienced their effects! Christopher Columbus was the first who traversed the region of the trades in their whole extent, from the shores of Africa to the islands of the West Indies He would have rendered his name immortal as the discoverer of the trade-winds, if he had not discovered America The boldness with which he entered on this navigation, and the firmness with which he followed it up, show the capacity of his mind, and the extent of his genius and knowledge. As he

had previously made several voyages to the Canaries, he had certainly acquired some knowledge respecting the direction and force of the trade-winds, but as these islands are only under their influence during a certain season, his information must have been far from being either correct or complete. Still he was not alarmed when he discovered that he was constantly sailing before the wind. It was otherwise with the crews of his vessels. At first they were well content at finding they were traversing a sea never agitated by a gale, and under the guidance of a wind always favourable, by which the laborious life of a sailor was converted into one of ease and comfort. But when after several days they became aware that the wind did not change, and was carrying them still farther from their own country, they began to fear that it would prevent them from ever returning to their homes. They then begged of their commander to turn back before they had got so far from home as to render it impossible to return for want of provisions. The great man was inexorable, and pursued his voyage. The wind still continuing to blow from the east, the crews became mutinous. They began to plot and to conspire, and at last to threaten their commander that they would throw him overboard if he persisted in advancing farther to the west. He was obliged to call into play the whole energy of his mind, the great authority he had obtained over his associates by his superior knowledge and talents, and his profound prudence, in order to obtain a respite of three days, under the promise that he would steer directly for Spain if in this time no land should be found. On the third day an island was seen. Thus the trade-winds and America were discovered at the same time, and Columbus returned to Europe by traversing the region of the variable winds, which lies contiguous to the trades on the north.

The trade-wind in the Northern Atlantic is called the *north-east trade*, because the wind blows from that quarter, or from some point near it. It extends over the sea which lies north of the equator, to about 30° N. lat. But there occur some changes in its direction as

well as in its extent, which are dependent on the position of the sun When the sun has a southern declination, or in other words, when its perpendicular rays fall on the southern hemisphere, the wind inclines more to the north, and varies between north-east and north-north-east, but seldom blows from the northward of north-north-east When the sun has a northern declination, or is in the northern hemisphere, the wind inclines more to east, blowing frequently from east-north-east, but rarely from the eastward of that point This is the direction of the north-east trade-wind near the Old Continent, along the western shores of Africa But in receding from these shores, and at a distance nearly equal between Africa and America, it becomes more easterly It often blows from due east, and sometimes even from the south of east, but in general it is one or two points north of east, and from these points it continues to the islands of the West Indies Captain Basil Hall differs somewhat from the account of other voyagers, stating that near the northern boundary-line, especially towards the Old Continent, the wind blows from due east, but soon declines gradually to the north-east, and eventually to the north-north-east, near its southern margin it turns even to the north

The changes which occur respecting the extent of the sea and the parts of the ocean in which these winds blow are much greater, and, as far as we know, are entirely dependent on the position of the sun When the sun has a southern declination, the trade-wind is not usually met with north of the Canaries, or north of 27° N lat., but when the sun is in the northern hemisphere the trade-winds prevail as far north as 32° N. lat., so that its northern boundary varies through five degrees of latitude The southern boundary of the north-east trade-wind in the Atlantic varies much more, according to the season of the year In December, when the sun is near the southern tropic, and in the three following months, the trade-wind ceases to blow when the equator is approached to a distance varying between two and seven degrees, so that then its mean boundary may be fixed at

five degrees from the line When the sun has passed the equator in proceeding northward, the southern boundary of the north-east trade in the Atlantic recedes gradually farther to the north, and in the three months following the summer solstice the trade-winds cease to blow at a distance from the line which varies between 9° and 15° N lat Its mean boundary in these months may be fixed at 12° N lat Thus we find that the difference between the mean boundaries in the three months following the winter and summer solstice is not less than seven degrees of latitude But when we take the extreme on both sides, we find that the difference amounts to thirteen degrees Thus it is evident that in summer the north-east trade prevails over an extent of sea comprehending twenty degrees of latitude, and that in winter the seas subject to its sway extend over twenty-two degrees These observations, however, are only applicable to the eastern parts of the Northern Atlantic, or those which lie near the African shores for on the side of America the trade-winds prevail all the year round to 30° N lat

This trade-wind is not very steady along its northern border, where it is sometimes interrupted by short calms, and at others by sudden puffs of wind It is also though rarely, replaced by a north-west wind, which blows with considerable force The wind, however, is always found steady and regular when the northern tropic is approached from the north, and also between this tropic and its southern boundary It blows with a gentle force, with what is called a *moderate breeze* which propels a fast-sailing vessel at the rate of five or six knots per hour; or with a *fresh* breeze, by means of which such a vessel may run seven or eight miles per hour. Vessels sailing before the trade make a hundred and twenty to a hundred and fifty miles a day, therefore the region of the trade-winds affords a very safe and easy navigation The vessel appears to descend a gently flowing river and the sailors are exempt from the numerous toils with which the navigation of the region of the variable winds is attended. They have hardly ever to touch the sails and

cordage. Even an open boat could venture to traverse the ocean in these parts. The Spaniards, when first navigating this sea, were so struck with the difference experienced in passing through the region of the trade-wind and the seas near Spain, that they called it the Sea of the Ladies, supposing that even ladies might muster courage enough to conduct a vessel through it, the more so as the variation of the temperature of the air between the night and day is so small that it hardly ever exceeds three degrees of Fahrenheit, and frequently not half that amount.

Persons who have gone to the West Indies in the track of the trade-winds, speak with rapture of this part of their voyage. They cannot enough praise the fine sunny weather, the fresh and pleasant eastern breeze, the clear blue canopy of heaven at night, lit up by the silvery moon and the effulgence of the stars. But nothing strikes their imagination more forcibly than the indescribable magnificence which is displayed before their eyes at sunset. The lower portion of the sky, almost from south-west to north-east, is overspread with a bright crimson ground, over which float light clouds in fairy forms of vapoury castles, islands, rocks, &c. of rich imperial purple, sombre, bronze, and brilliant golden hues. Above these fairy apparitions the crimson gradually fades into a delicate blush, which, near the zenith, mingles with the dark blue by which the sky of the intertropical zones is distinguished.

Vessels sailing from Europe to the West Indies and the countries which surround the Gulf of Mexico and the Caribbean Sea, commonly take advantage of the trade-winds. In the beginning of their voyage they do not try to make westing, but sail southward until they reach the region of these winds, passing the island of Madeira and the Canaries. Nor do they turn to the west immediately they have passed the last-mentioned group, because they know that in the sea lying west of them the trade-winds are still unsteady, and frequently interrupted by calms, light winds, and puffs. They continue, therefore, their course southerly until they have passed the tropics,

when they turn westward, and steer directly to the place to which they are bound. Along this track a voyage from Cape Lizard to Kingston in Jamaica amounts to nearly 5000 sea miles. A vessel departing from Cape Lizard for Jamaica, and traversing the Atlantic obliquely, in a straight line between the two points, has only to make a voyage of about 3800 miles. The last track is shorter, therefore, by 1200 miles. Though along the last-mentioned track the vessel has frequently to contend with contrary winds, it has been ascertained that the voyage is commonly accomplished in a less time than that which lies across the whole extent of the trade winds; so that probably the last-mentioned route will ultimately be entirely abandoned by vessels bound to the West Indies. This is not to be attributed to better information on this point, but to the high degree of perfection all branches of science and mechanic art have attained in our times, which refer to navigation. The advantages the region of the variable winds offer, may, by the skilful seaman, be turned to such an account as to enable him to accomplish the voyage in a straight line in a shorter time than he would have done if he had followed the track through the region of the trade-winds.

The north-east trade blows home to the very shores of the American continent, surrounding the islands of the West Indies, but it does not blow near the coast of the Old Continent, being there separated from them by a tract of sea in which westerly winds prevail. This tract extends to fifty miles or more off shore. This irregularity is to be ascribed to the effects which the hot desert of the Sahara produces in the atmosphere. The surface of this desert, which consists of loose sand and is almost without any trace of vegetation, is heated by the sun's rays to an excessive degree, and this has the effect of greatly rarefying the superincumbent air, and of rendering it less dense than the air which covers the sea contiguous to the desert. When, therefore, the air of the desert comes into contact with that of the sea, this latter rushes over the desert to re-establish the equilibrium of the atmosphere, and the current of air thus

produced is the westerly wind, which is met everywhere along the African shores, as far south as the Cape Verde Islands. These shores have acquired a bad repute on account of the numerous shipwrecks which have happened there. This is partly to be ascribed to the westerly wind which blows directly in shore, but also to a current which runs along the shore southward, and at some places sets directly in shore, so that a vessel which is so unfortunate as to become entangled between this wind and the current, can hardly hope to make its escape, even by the most strenuous efforts of the crew.

When the navigator emerges from the region of the north-east trades, after passing their southern boundary, he enters *the region of the calms*. This region, like the trade-winds, does not occupy all the year round the same portion of the ocean, for it likewise follows the march of the sun, extending farther northward when the sun has a northern declination, and receding southward when it enters the southern hemisphere. We have seen already that its mean northern boundary in the month of the winter solstice lies at about 5° N. lat., and in those which follow the summer solstice at about 12° N. lat. Its southern mean boundary is always found to the north of the line. When the sun is in the northern hemisphere, it advances so far northward, that sometimes the south-east monsoon is found at a distance of 6° north of the line and the parallel of 3° N. lat. may be considered as the southern boundary of the region of calms, for all the time from the month of May to that of October, including these months, or for half a year. Even in November and December the south-east wind is frequently met as far to the north. But in the three months following the winter solstice the southern boundary of the region of calms lies nearer the equator, in general only one degree north of it, and occasionally it recedes to one or even two degrees south of the line. During this period of the year the mean width of the region of calms extends over about four degrees, from 1° to 5° N. lat. In the three months succeeding the summer solstice it is much wider,

as it occupies the whole region lying between 3° and 9° N lat, or six degrees of latitude

This region has received its name from the calms which generally prevail over its whole extent, but more especially along its northern margin. The dead calms, however, are frequently interrupted by light airs, which are hardly sufficient to give steerage-way Occasionally very violent tornadoes or squalls are experienced, tearing away, in a moment, every rag of canvass from the ship's yards Its climate is the reverse of that of the region of the trade-winds, the weather being damp, foggy, cloudy, and gloomy, and almost every day some sudden gusts of wind, accompanied by thunder and lightning, are experienced For several hours at a time rain falls in absolute torrents All these circumstances concur to render the navigation across this region extremely tedious and unpleasant. Even fast-sailing vessels cannot average more than thirty miles per day, frequently much less. There are instances on record of a vessel having been kept stationary for more than twenty-four hours, and even of its having lost a few miles of the progress it had made the day before It takes a vessel commonly eight or ten days to get through this region, and it would take her still more if the trade-winds, by which it is enclosed on the north and south, did not frequently encroach on its outer borders to a distance of about thirty miles from the boundary of the calms It is, however, certain that vessels sailing to the north traverse the region of calms in a shorter time than those which cross it in a southern direction This is to be ascribed to the direction of the light breezes, which frequently interrupt the calms, and commonly blow from the south or south-west, rarely from the north of west

It is a very fortunate circumstance for the maritime intercourse between Europe and South America, that in summer the southern boundary of the region of calms lies 5° north of the equator, and that in the space between this boundary and the line a steady south-east monsoon is met with, for in this season the equatorial

current runs with great force. This current flows from east to west along the equator, but more to the south than to the north of it, occupying generally a width of 5° of latitude. Its force in our winter months does not commonly exceed two knots per hour, and is frequently much less, but in July and August it runs at the rate of from three knots to three knots and a half. If this current was within the region of the calms, both together would almost form an insuperable barrier to the progress of vessels navigating these seas. Even at present, the equatorial current sometimes carries vessels sailing from Europe to South America out of their course. If a vessel bound on such a voyage crosses the equator to the west of 23° W. long., when the current runs with great force, it is frequently carried forcibly to the west beyond Cape St Roque in Brazil, where it is driven towards the northern shores of Brazil, and when that takes place, weeks and even months of toilsome labour are required to bring the vessel back to its proper course.

The southern boundary of the region of calms is the northern boundary of the *south-east* trade-wind, which reaches southward, when the sun has a southern declination, to 30° S. lat., and in the opposite season to about 28° S. lat. Its sway therefore extends over a much greater space of the Atlantic than that of the north-east trade-wind. When the sun is in the southern hemisphere, the whole of the ocean between 1° N. lat. and 30° S. lat. is swept by this trade. Its width therefore is 31° of lat., or 9° more than that of the region of the north-east trade. Its mean width in the opposite season is not less, as then it extends from 3° N. lat. to 28° S. lat., whilst in this period of the year the north-east trade is only found to prevail over 20° of lat.

This wind in general blows from the south-east, but in this direction it undergoes greater changes than the north-east trade-wind. Along the western shores of Africa it blows from the south, declining frequently to the south-south-west, and even to the south-west. This remarkable change of direction is ascribed partly to the

great elevation to which Southern Africa rises, and partly to the peculiar formation of the Bight of Benin. That the first circumstance exercises some influence on the direction of the wind is evident from its diminishing in force in proportion as we approach the shores of the continent In its vicinity the wind dies away into calms, which frequently are interrupted by light airs, and sometimes by light and even fresh breezes In receding from the continent, the wind gradually passes more to the east The meridian of 10° W of Greenwich may be considered as a line of separation between the winds which blow from the south and those from the east To the east of that line the wind varies between south-west and south-south-east, and to the west of it between south-south-east and east-south-east It hardly ever blows from due east, even near the American continent Captain Basil Hall differs here from other navigators According to his statement the south-east trade blows, near the equator, from the south, but more to the south it declines to the south-east, and still farther on to east-south-east, until it reaches its southern margin, where it eventually blows from the east

Along that border which looks towards the antarctic pole, this trade-wind, like the north-eastern, is frequently interrupted by calms, light breezes, and sudden gusts, but the variable winds hardly ever encroach on the region subject to its sway. Otherwise it is more regular, and blows with rather greater force than the north-east monsoon It commonly blows with a fresh breeze, and sometimes freshens to a strong breeze, so that a fast-sailing vessel, sailing before the wind, may run from eight to ten knots per hour

This trade-wind is very favourable to the vessels which return from the East Indies and from China It is especially by its aid that these vessels commonly accomplish the voyage from the Cape to Cape Lizard in the short period of sixty days It is, however, less favourable to those which are on their voyage from the British Channel to the Cape Though its steadiness, and the force with which it blows, favour in a considerable de-

gree the progress of the vessels, its blowing from the place to which their course is directed prevents them from making a rapid progress. At present, therefore, such vessels rather avoid opposing the wind. They sail, after having passed the line near 23° W. long., along the shores of South America until they have reached the southern tropic, when they decline their course to the south-east, and soon enter the region of the variable winds, which here, as in the northern hemisphere, extends from the outer boundary of the south-east trade to the antarctic pole.

The progress of the vessels which follow this track is greatly promoted, for four or five months of the year, when the sun is in the southern hemisphere, by a wind which, along the shores of Brazil, and to a considerable distance from them, blows from between north-north-east and east. This wind owes its origin to the circumstance of the elevated table-land of Brazil, during the sun's stay in the southern hemisphere, acquiring a considerable degree of heat, which, by being communicated to the superincumbent air, produces such a rarefaction in the atmosphere, that the denser air which extends over the surface of the adjacent sea is continually advancing towards those parts of the South American continent where this rarefaction is going on, in the same manner as we have observed it before, when speaking of the effects of the Sahara in producing a wind contrary to the direction of the north-east trade-wind. This wind blows with the force of a moderate or strong breeze, like the trade-wind itself.

Such a great and marked difference between the trade-winds and the variable winds necessarily struck the scientific men who had applied their minds to the task of explaining the phenomena, and they began to account for their origin by appealing to the laws of nature as far as they were known at the time. It was first considered that the trade-winds owed their origin to the revolutions of the earth round its axis, and to the circumstance that the atmosphere, though it participated in that motion, could not follow with equal speed the motion of the denser parts of our globe.

This of course must produce a current in the air having a contrary direction to that of the earth round its axis, and moving from east to west The strongest proof which could be produced in support of this explanation was the circumstance that the trade winds occur only in the lower latitudes, where the surface of the earth, in its revolution round its axis, has to make a large circle in twenty-four hours, and consequently must move with a greater degree of rapidity than in the higher latitudes. This explanation originated with the Italian philosopher Galileo, but our countryman Halley, having collected more exact information respecting these winds, pointed out several facts which were incompatible with the opinion of Galileo. The two most decisive points were, that there are no trade-winds contiguous to the equator on the northern side, where the diurnal motion of the earth is much greater than at many other places where trade-winds are met with, and next, that the trade-winds change their position according to the seasons which could not take place if they were only the effect of the rotation of the earth. He proposed therefore another explanation of these phenomena His theory rests on the well-established principle that wind is only a current of the air, or a part of our atmosphere in a state of more or less rapid motion, and that its principal cause is a partial or local rarefaction of the air by heat When the air at a place is heated, it strives to occupy a larger space, and as at the same moment it has become lighter, it is enabled to rise higher into the atmosphere If, under such circumstances, the air superincumbent on a contiguous place is not heated to the same degree, it preserves a greater density, and this less rarefied or colder air rushes into the place occupied by the lighter air to restore the equilibrium The current of air thus produced is what is called a wind Supported by this principle, Halley ascribes the origin of the trade-winds to the rarefaction produced in our atmosphere by the apparent diurnal progress of the sun It appears that the heat caused by the sun in the air is strong enough to produce this rarefaction to an extent of about 60° of latitude, as the trade-

winds, including the region of calms, extend over such a portion of the globe. In this immense space the rarefied air is replaced by the colder and denser air which rests over the region contiguous to the region of the trade-winds, and this transportation of air is the trade-wind. As the difference of the density of the two portions of air which are brought into contact with one another is not great, the wind is of moderate force.

To this theory of Halley an objection is made by Hadley. He says that rarefaction alone cannot be the cause of the trade-winds, as in that case the air would rush in from all sides to that place where the rarefaction was greatest, and especially so from the north and south, where the air is certainly much cooler and denser. The wind, therefore cannot blow from the east. The coolest portion of the atmosphere lying before the progress of the sun is, on the north of the line certainly in the north-west, and that lying behind its course is in the north-east. Therefore rarefaction must, on the north of the equator, produce a north-west wind in the morning and a north-east wind in the afternoon. In the southern hemisphere, the sun would be preceded by a south-west wind, and it would be followed by a south-east wind.

It appears, however, that in laying down this principle, Hadley did not bear in mind, that by the effect of the sun's rays the air superincumbent on the intertropical regions, as also the sea and land, is heated to such a degree that the variation of temperature in twenty-four hours does not amount to more than a degree, or a degree and a half, that the air of the temperate region adjacent the tropics is nearly as much heated, and that the variation of temperature is not much greater, but that in retiring farther from the tropics to the north and south, the air gets cooler in proportion to the distance from them. In such circumstances the air must always flow gently from the south and north towards the intertropical countries; and the rarefaction can only produce a hardly perceptible increase of the wind, the air being supplied by the region adjacent to that in which the greatest rarefaction takes place, which in the

northern hemisphere is placed to the north, and in the southern to the south, of the intertropical countries

Mr. Dalton, who adopts the theory of Hadley, makes another objection to that of Halley, saying—"Had the trade-winds been produced by the daily rarefaction of the air alone, independent of the earth's rotation, they should have extended to 50° N lat. when the sun is in the tropic of Cancer, because the heat at that parallel is then as great as at 30° of S latitude, in fact, they ought to have extended in a greater or less degree over the ocean from the equator to the poles, and the summers have been more tempestuous than the winters, because the daily variation in heat is then greatest" So it certainly would be, if the counter-current in the upper regions of the atmosphere, of which we shall speak presently, did not exist But the air of this counter-current, when it arrives at the outer boundaries of the trade-winds, has been cooled and condensed to such a degree, that it is enabled to press down to the surface of the globe, and to change entirely the direction of the wind

It appears that the greatest objection to the adoption of the theory of Halley is the circumstance, that the trade-winds do not blow from due north and south, but from north-east and south-east This phenomenon may perhaps be explained in the following way --If the wind could flow with a degree of velocity equal to the progress of the sun, it would blow from due north on the northern side of the places which are under the influence of the perpendicular rays of the sun, and from due south on the southern side of such places But the velocity of the aerial current is infinitely less than that of the earth. Hence it follows, that the wind has hardly taken the direction which is imparted to it by the rarefaction of one place, when the place of the greatest rarefaction has already changed, having proceeded farther west. This causes the wind to decline to the place of the greatest rarefaction, and thus the northern wind is converted into a north-eastern and the southern into a south-eastern wind. When we further consider that this progress in the

atmosphere is rapidly extending westward—if not interrupted by the intervention of the land—we easily conceive how the quick progress of the rarefaction towards the west insensibly influences still more the direction of the wind, and hence it is found that in the western portion of the Atlantic the trade-wind blows nearly from due east. Where the trade-wind does not exactly follow this course, its direction has been disturbed by the localities of the adjacent continents, as we have mentioned in speaking of the effects of the Sahara, the high land of Africa, and the table-land of Brazil.

George Hadley, the brother of the inventor of the quadrant, proposed another theory, which for a long time was neglected and overlooked, but lately has been brought forward by Dalton and Daniell. It is a partial revival of the theory of Galileo. He supposes, as Halley does, that there exists a continual flow of air from both the north and south towards the equator; that in the neighbourhood of the poles, and as far from them as the polar boundaries of the trade-winds, the pressure of the air is sufficient to keep it firmly fixed to the places on which it rests, so that no regular current to the west is formed; but that in the tract where the trade-winds are formed, the rotatory velocity of the earth is so great, that the pressure of the air is not sufficient to keep it in its position, and that within the region of the trade-winds the earth moves with greater velocity than the superincumbent air, which difference of motion produces the trade-winds. "The two general masses of air," says Dalton, "proceeding from both hemispheres towards the equator, as they advance are constantly deflected more and more towards the east on account of the earth's rotation; that from the northern hemisphere, originally a north wind, is made to veer more and more towards the east, and that of the southern hemisphere in like manner to veer from the southward towards the east: these two masses meeting about the equator, or in the torrid zone, their velocities north and south destroy each other, and they proceed afterwards with their common

velocity from east to west round the torrid zone, excepting the irregularities produced by the continents."

A theory conceived for the explanation of a natural phenomenon can only be called perfect when all the peculiarities by which the phenomenon is attended can be explained according to the known laws of nature. That theory which explains the greater number of these peculiarities is nearest the truth. Examining the theories of Halley and Hadley on this principle, we must give the preference to the former, as it accounts for all peculiarities of the trade-winds in a satisfactory way, with the exception of the region of the calms, and its peculiar nature. The theory of Hadley assigns no reason for the change of the position of the trade-winds according to the seasons, nor for the difference in their direction near the Old and New Continents. Neither does it explain why, in those places of the globe where the rotatory velocity of the earth is greatest, no constant current of air is met with.

Halley, according to the principles above explained, supposed that the heated and rarefied air rises above the more dense portion of the atmosphere, and when it has arrived at a certain elevation above the surface of the globe, it is condensed by the cold which there always prevails, and is thus enabled to sink again lower down. But being unable to return to its former plane, which has been occupied by a colder and denser air, it flows off towards the poles, or rather towards those parts which have supplied the air to the rarefied plane. This expanse of the upper air takes a direction quite opposed to that of the trade-winds, namely, to the north-west, from which quarter the greater part of the air had been derived which occupied their place within the region of the trade-winds. Thus two currents of air are found within the trade-winds, of which the lower flows to the south-west north of the line and to the north-west south of it, whilst the upper currents run in the opposite directions. As by their longer stay in the more elevated regions of the atmosphere these upper currents become more and more

condensed, they by degrees acquire a density which enables them to descend to the surface of the globe, which, however, only takes place when they have arrived beyond the outer boundary lines of the trade-winds. To this process of nature it is ascribed that within the region of the variable winds those which blow from the south-west in the northern, and from the north-west in the southern hemisphere, have a considerable preponderance over those which blow from other quarters. This last circumstance certainly is in favour of the existence of two upper currents; but still it was considered only as a theory, which required to be confirmed by facts, until in 1812 an event occurred which established at once its solidity. In the eruption of the volcano of St Vincent, considerable quantities of ashes and other volcanic matter descended on, and spread over, the island of Barbadoes. This event excited, at that time, a high degree of surprise, as in this part of the Columbian Sea the trade-wind always blows with considerable force, so that vessels sailing from St Vincent to Barbadoes are obliged to make a circuitous course of some hundred miles to reach the place of their destination. The ashes, therefore, had been carried against the prevailing wind. It can hardly be questioned that the volcanic matter was raised by the eruption of the volcano to such an elevation that it reached the counter-current, which, blowing from the west, carried it to Barbadoes.

As the Pacific Ocean is at least three times as large as the Atlantic, it was supposed that the laws of nature had there a less impeded sway, and that consequently the trade-winds must be there much more regular than in the seas between Africa and America. This supposition received some support from the accounts of the navigators who visited the Pacific in the last century. But by the numerous voyages which have been made in those seas since the beginning of this century, our information respecting them has been greatly increased, and it tends by no means to confirm the opinion which had been formerly conceived respecting the trade-winds in this ocean. On the contrary, it appears that hardly

one-half of the Pacific, which according to the former opinion should be continually swept by the trade-winds, is under their uninterrupted influence.

As to the boundaries of the two trade-winds, it does not appear that there is any considerable difference between the Pacific and the Atlantic, at least not as regards the southern boundary of the south-east and the northern boundary of the north-east winds. The first lies, when the sun is in the southern hemisphere, between 30 and 31° S. lat., and when it has a northern declination near 25° S. lat. The northern boundary of the north-east trade is also found to vary between 26° and 30°. But where the two boundaries lie which divide the trade-winds from the region of calms has not yet been ascertained, as the accounts offer considerable anomalies, which cannot yet be reconciled. It is however certain, that here too the region of calms is found north of the equator, but perhaps at a mean not more than three or four degrees, and that it sometimes extends to twelve degrees and more from the line northward.

But in the Pacific the trade-winds do not approach so near the western coasts of America, as in the Atlantic to those of Africa. Along the shores of South America a southern wind always blows, and this wind extends to a distance of from four hundred to five hundred miles from the continent. Beyond that distance a steady regular trade-wind is met with, which near the equator blows from south-east, but farther south gradually declines to east and even east-north-east. It is very probable that the high mountain-masses of the Andes prevent the south-east trade from approaching nearer the continent of South America. Still greater is the space which separates the north-east trade from the shores of Mexico and Central America. Here the regular winds are only found at a distance of from six to seven hundred miles from the coast, from the beginning of May to the end of December, and during this period western and south-western winds prevail in the northern, and north-westerly winds in the southern, portions of this large tract of sea.

With the last-mentioned exception, the whole sea between America and the eastern shores of the island of Formosa and of China is under the regular sway of the north-east trade, which is only interrupted by the Ladrones, a group of islands extending north and south over more than seven degrees, and on the west of which south-western and western winds are prevalent, at least during the period that the sun has a northern declination The group of the Sandwich Islands lies in the direction of the trade-winds, and does not interrupt their course further than that, in the immediate vicinity of them, the daily alternation of sea and land breezes is experienced

The south-east trade-wind, however, if considered as a regular perpetual wind traverses only over the smaller portion of that region which should be under its dominion, and this lies towards the American continent, between 90 and 140° W long The sea which lies west of 140 W long is as it were dotted with groups of islands or isolated islets In this region the trade-wind seems to be converted into a monsoon, that is, a wind which during one-half of the year blows from one direction, and the other half from the opposite one We owe the first observation on this anomaly of the south-east trade-wind to Captain FitzRoy, who in speaking of the Paamuto Islands, or the Dangerous Archipelago of the Low Islands, observes that among them a steady south-easterly trade wind prevails only from March to October, but that when the sun is in the southern hemisphere, westerly winds, squalls, and rains are frequent Later accounts give us much more exact information respecting these changes It has now been ascertained that a westerly or north-westerly monsoon blows with steadiness, force, and great regularity along the northern shores of New Guinea at New Britain, New Ireland, and all the contiguous islands south of the equator as far westward as Rotumah (178 E long) It continues eastward to the Society Islands and the Marquesas, but decreasing gradually in strength and steadiness This monsoon commences blowing with force in December or January, is

attended in February with squalls and heavy rain, and in April and May is replaced by variable winds In June the south-east trade or monsoon sets in strongly with heavy rains and squalls, and continues so until the end of August In September the strength of the south-east monsoon—for so it must be named on account of the rainy weather with which it is attended—is spent, and the weather is more moderate from this time until the return of the north-west monsoon These monsoons are met with in the Pacific from 1° N lat and 15 S. lat, and occasionally so far south as 19° S lat but their mean southern boundary may be fixed at 13 S lat They change their character, however, east of the island of Rotumah The westerly monsoon is less constant, but blows with force for seventeen or eighteen days, when it abates, and is soon replaced by an easterly wind, which blows with a fresh breeze for nearly the same period, when westerly winds again commence, usually beginning with a gale, and always continuing with a strong breeze, with squalls and rain Thus the easterly and westerly winds blow alternately from December to the end of March, when the south-east trade sets in with steadiness and fine weather

In this manner the south-east trade is replaced by monsoons in the western seas of the Southern Pacific. It is somewhat difficult to account for this apparent anomaly, but all circumstances appear to prove that we must look for the cause of these changes to the almost innumerable islands and coral rocks which cover this part of the ocean, and some clue to the solution of the question may be found in the observations of an attentive observer (Horsburgh), who says that "where shoal coral banks shoot up out of the deep water, in many places between the tropics, a decrease of the prevailing wind is frequently experienced For when a steady wind is blowing over the surface of the deep water, no sooner does a ship get upon the verge of a shoal coral bank than a sudden decrease of the wind is often perceived This is occasioned by the atmosphere over these banks being less rarefied by the increased evaporation than that over-

the deep water, and consequently not requiring so great a supply of air to restore the equilibrium as the adjacent parts, which are more heated and rarefied." When a single coral bank, lying in the way of a trade-wind which has blown regularly over an extent of many hundred miles, is thus able to cause a very perceptible decrease in the strength of the wind, we may easily comprehend that their great number and extent in the Southern Pacific is able not only to change slightly the direction of the wind, but even to turn it to the opposite quarter,* and thus to exercise an influence on the state of the atmosphere, nearly, if not entirely, equal to that of a large continent.

The discovery of this monsoon has at once set to rest a question which for a long time had puzzled the heads of men. When most of these islands were discovered, the very curious fact was ascertained at the same time that its inhabitants belonged to the Malay race. The conformation of their bodies, their language, and a great number of their usages, showed such a similarity to those of the Malays, that not the least doubt remained on the minds of those who had an opportunity of becoming acquainted with these nations as regarded their origin. Now it was already known that the islands of Sumatra and Java, together with the Malay peninsula, must be considered as the true native places of this race, and that they had spread from these places over the adjacent islands. Moreover, there were good reasons for the supposition that the inhabitants of the islands of the Pacific had arrived there by advancing from west to east. But how was such a migration to be comprehended, when it could only be effected by navigating in open boats against a constant trade-wind which blows with considerable force? At present, it is evident that the same north-west monsoon which carried the Malays to the Moluccas has opened them the road to the Viji, Friendly, and Society Islands, and that this nation has thus been enabled to take possession even of the most eastern of the Paamuto Islands.

The trade-winds are not only met with on the sea.

Countries of great extent are found, on both continents, in which they prevail But such countries must not be raised much above the sea-level, and must besides have a level surface, where nothing occurs that can break the force of the wind or change its direction For if the wind comes in contact with high land or mountains, its regular progress is obstructed, and its course deflected into a different direction O r a considerable tract of low land, however, the wind passes without being much changed in its direction and velocity, particularly if the land be barren and destitute of moisture The largest of such plains is the Sahara, a Great Desert of Africa, where a strong eastern wind always prevails, which in daytime frequently increases to a gale, but towards evening abates, and at night mostly lulls into a dead calm In the eastern districts of the desert, the surface of which is more diversified by depressions and eminences, and at some places by short and low rocky ridges, the wind is less constant, and blows with less violence. An easterly wind passes also almost without interruption, over the woody plain drained by the river Amazonas By its assistance the voyage against the strong current of the river may be accomplished in nearly the same time as the voyage downwards by means of the current This wind is moderate near the mouth of the river, but increases in strength in proportion as it ascends, and at the base of the Andes has acquired such force, that it is almost impossible to keep one's footing against it. A similar easterly wind, though of less strength, is nearly always sweeping over the vast and treeless plain traversed by the lower course of the Orinoco.

Section IX.—Monsoons.

The trade-winds, as we have seen, blow the whole year round from the same quarter. Though they facilitate the navigation of those seas in which they are found, they do it only in one direction, and greatly retard the progress of vessels which have to pursue the opposite course. A vessel bearing up against the trades can only advance by tacking, and then but slowly. Such vessels, therefore, try to avoid the wind, where it is possible, by a circuitous route, and through seas where variable winds prevail. This, however, would, in most cases, carry them too far out of the direct course. They prefer therefore, to sail, by the assistance of the trade-winds, either to the north or south, and continue in such a direction for several hundred miles, until they think that they have arrived at a place from which, by another tack, they can fetch the port to which they are bound. It is easy to conceive that such voyages must be extremely tedious, which is also confirmed by the great difference of time in which the out-voyages and the return-voyages are performed between two places lying east and west of one another, and within the influence of the trade-winds. For instance, ships which leave Jamaica, and are bound to the Virgin Islands, Antigua, or St. Kitts, take several weeks to accomplish the voyage, whilst they return from the last-mentioned place to Jamaica in a few days. The navigation between the different islands of the Canaries is attended with the same circumstances. During the prevalence of the trade-winds in these seas a vessel can run from Teneriffe to Hierro in less than one day, but to return from Hierro to Teneriffe generally takes ten or twelve days, and sometimes even three or four weeks.

But winds prevail in another part of the ocean which are much more favourable to navigation These winds blow for six months of the year in one direction, and for the other six in an opposite course They are, therefore, called periodical winds They are almost entirely limited to the northern part of the Indian Ocean Most of the countries and islands surrounded by the sea in which they prevail are inhabited by Malays In the language of these people they are called *moosem*, a term which properly signifies year or season This term has been received into the English language in the corrupted form *monsoons*

The monsoons do not sweep over the whole of the Indian Ocean. In its most southern parts variable winds prevail, which are met with in the seas extending from the antarctic pole as far north as 28° or 29° S lat North of this parallel the sea is subject to the south-east trade, which however, in the Indian Ocean sweeps over a much smaller extent of sea than in the Atlantic or Pacific Ocean In the Indian seas it does not usually reach farther north than 13° or 12° S lat., though occasionally it advances to 10° S lat The parallel of 12° S lat may be considered as the mean northern boundary of the south-east trade in the Indian Ocean

This parallel is the southern boundary of the monsoons, which hence rule over the whole ocean to its most northern recesses Before we enter into a detailed account of these winds, and the peculiarities with which they are attended, it must be noticed that at no season of the year is the whole extent of the sea under the sway of one monsoon but that all the year round two monsoons are sweeping its surface They blow from different but not opposite quarters It must not, however, be imagined that both monsoons prevail on the same portion of the sea at the same time, either alternately or otherwise, but that one of them sweeps one portion of it, whilst the other is subject to another monsoon The line which separates the two monsoons blowing at the same time lies near the equator, and this great

circle may, therefore, be considered as their common boundary As those monsoons which prevail north of the equator have most attracted the attention of Europeans, on account of the great influence they exercise on their commercial intercourse with India and China, it seems advisable to take notice of them first

On the north of the equator the Indian Ocean consists of three large gulfs, which, proceeding from west to east are called the Arabian Sea, the Bengal Sea, or Gulf of Bengal, and the Chinese Sea In these three seas a north-eastern wind prevails when the sun has a southern declination, or from October to April, and a south-western wind when the sun's perpendicular rays fall on the northern hemisphere, from April to October. The first is called the north east, and the second the south-west monsoon.

It is not quite correct to say that either of these monsoons blows for six months They hardly anywhere prevail for more than five months, and there are two months of the year in which no monsoon is met with in the Indian Ocean, namely, from the middle of March to the middle of April, and from the middle of September to the middle of October At these periods the changes of the monsoons are effected At some places it occurs a week or two sooner, and at others later When one of the monsoons is about to cease, the winds grow gradually weaker, and are occasionally replaced by calms. The atmosphere, even on the sea, begins to be in a disturbed state, the air becoming sultry, heavy, and foggy, and the sky overcast The winds also frequently change the quarter from which they blow, and are accompanied with gales, hurricanes, thunder-storms, and rains After this state of the atmosphere has continued for three or four weeks, the weather changes, and the other monsoon sets in. It is certainly a remarkable, but well-established fact, that as soon as one of the monsoons ceases, the clouds in the upper region of the atmosphere take the direction of the opposite monsoon, though several weeks must pass before this monsoon descends to the

lower strata of the atmosphere, and becomes prevalent on the surface of the sea

The *north-east* blows from November to March It extends at some places to one or two degrees south of the equator, and blows with the greatest regularity and force in the Arabian Sea Along the eastern shores of Africa it becomes sooner settled than in the middle of the sea, and near the equator sooner than at Cape Guardafui and along the coasts of Arabia It blows in this sea with the greatest force in the month of January, and is most violent in the northern parts, especially between the island of Socotra and Bombay When steam-navigation was introduced in India, the first steamer which left Bombay for the Red Sea found the wind so violent, and received such damage, that she was obliged to return to Bombay This monsoon does not bring rain to the countries surrounding the Arabian Sea on the east and north, but during its prevalence the eastern shores of Africa have their wet season, rain falling abundantly from the beginning of November to the end of March It must, however, be observed, as an ascertained fact, that the monsoons do not bring rain in themselves, as not a drop of rain commonly falls on the sea during their prevalence, but no sooner does the monsoon reach the shores of a country than the rain pours down

In the Bay of Bengal the north-east monsoon makes its appearance somewhat later It does not regularly set in, nor does it blow with force, before the beginning of December, when it blows from east-north-east or north-north-east In January it is commonly subject to irregularity in strength, and frequently declines to south-east In March it ceases entirely in the centre of the gulf, where it is commonly replaced by calms and some light variable winds In the north-eastern parts of the gulf, and along its shores, it then blows faintly, with long intervals of calms Though this monsoon in the Gulf of Bengal remains unsettled till December, it is preceded for five or six weeks by heavy squalls and

winds in the southern parts of the sea, especially along the coast of Coromandel, and it is during these squalls that this part of Hindustan is fertilized by abundant rains.

In the Chinese Sea, and those parts of the Indian Ocean which are immediately connected with it, the north-east monsoon is also subject to some irregularities. It blows there with more uniform strength than in the Gulf of Bengal, but its direction undergoes many changes, which are to be ascribed chiefly to the direction of the coast which surrounds the Chinese Sea. In the sea which separates the Philippine Islands from China it blows regularly from the north-east, but in the Bay of Tonquin it declines to the north-north-east, and along the coasts of Cochin-China it proceeds from due east, whilst in the Gulf of Siam it comes from the north from November to January, but during the remainder of its prevalence declines more to east. This monsoon brings rain to all the countries which enclose the Chinese Sea on the west and south. Where the winds blow directly in-shore, as they do with Cochin-China Proper and the northern coasts of Borneo, the rains are very abundant. A trust-worthy traveller states that during his stay at Turon Bay, in Cochin-China, the rains were so abundant and incessant for more than twenty-four hours, that the surface of the sea was covered with a stratum of fresh water, which was found good enough for culinary purposes, and the casks of his vessel were filled with it.

The *south-west* monsoon does not reach the equator, but is usually met with at a short distance north of the line. It blows from the middle of April to the end of September. Like the other monsoon, it is most regular, and blows with the greatest force, in the Arabian Sea. Along the coast of Africa, being influenced by the trending of the shores, it blows from south-south-west, and there it makes its appearance as early as the end of March, but along the western shores of Hindustan it is not met with before the 12th of April. Along the shores of the last-named country it advances gradually from south to north, se-

ting in sooner on the coasts of Travancore and Malabar than on those of Canara and Concan At Anjengo (8° 30′ N lat) it sets regularly in on the 12th of April, but at Bombay (19° N lat) not before the 15th of May, so that its progress extends only at the rate of one degree of latitude in about three days It reaches the coasts of Arabia and Beloochistan still later This monsoon brings rain to the western shores of Hindustan. The rains are very abundant in the southern districts, but decrease gradually in proceeding farther north. At Tellicherry (12° N lat) the annual quantity of rain amounts to 116 inches, but at Bombay it does not exceed 63 inches, and the delta of the Indus probably has not more rain than the vicinity of London (20 inches)

In the Bay of Bengal the south-west monsoon is more regular in strength than the north-east monsoon, but varies more in direction, for it blows frequently from the south and even from the south-east, especially near the mouths of the Ganges Hardly any rain falls during the prevalence of this wind on the western shores of the Bengal Sea, but there are very abundant rains on the northern and eastern shores These rains fertilize the great plain of Bengal by raising the waters of the Ganges above its banks, and laying under water an immense tract of country They extend over the plain to the very base and even over the lower declivities of the Himalaya Mountains, and along this range as far north as the point whence the Ganges issues from the mountains But the quantity decreases as the rain advances farther northward. The annual quantity of rain at Calcutta is 72 inches, but at Benares not more than 46 inches fall annually, and still less in the level country which extends farther to the north and west The greatest quantity of rain, however, appears to fall on those countries which enclose the Bay of Bengal on the east, especially on those adjacent to its northern parts, in Chittagong and Aracan, where, according to a rough estimate founded on partial observations, the annual amount of rain is not less than 200 inches

In the Chinese Sea the south-west monsoon hangs more

to the south than the west, blowing in general from south-south-west. Its strength is considerable, and it is never interrupted with calms, except near the equator, but is sometimes accompanied by high winds. In this sea, too, this monsoon brings rain to all the countries lying to the north and east of it. In the Philippine Islands, and along the southern shores of China, the rainy season sets in about the beginning of May, and continues to the end of September or the beginning of October. These rains must be called abundant, when compared with the quantity which falls on the countries without the tropics, but they are scanty, when put in comparison with those of Bengal, the coast of Malabar, or Chittagong.

It is not possible to determine exactly the place where the north-east monsoon terminates on the side of the Pacific, as in these parts its direction does not materially differ from the trade-wind which sweeps over the northern portion of that ocean. But as the south-west monsoon blows in an opposite direction, it is clear that there must be a place where it terminates, and where the trade-wind begins. Some authors are of opinion that the monsoon extends as far north as Kiusiu, the most southern of the Japanese islands, but it appears that it does not reach so far, and that it ceases to blow near 27° N. lat. A similar disagreement exists respecting its eastern boundary. Most authors maintain, that in that direction it extends to the Ladrones. They rest their opinion on the circumstance that west of these islands the western and south-western winds prevail in summer, but it appears that this wind has no connexion with the monsoon, as in these oceans, between the Ladrones and Philippines, a tract of sea occurs several degrees in width, where the eastern trade-wind is met with all the year round. According to the greater number of facts which we have for determining this point, it would seem that the eastern boundary of the south-west monsoon must be fixed near the meridian of 136° E. of Greenwich.

As soon as the peculiar nature of these extraordinary winds was known, and the phenomena by which they are attended, an explanation of their origin was sought for

and tested. It appeared that this explanation could not be founded on a firmer base than by resting it on the same principles by the application of which Halley had succeeded in explaining in a satisfactory way the origin of the trade-winds. For this purpose it was pointed out, that the Indian Ocean differs greatly from all other large portions of the sea lying within the tropics, as it is on all sides surrounded by land, except on the south-west. Though there is a large open space of sea between the eastern coast of Africa and the island of Madagascar on one side and the north-western shore of Australia on the other, yet these countries, consisting mostly of sandy desert, must greatly affect the state of the atmosphere when their surface is heated to a great degree by the long stay of the perpendicular rays of the sun Hence it seems to follow, that when the sun is in the southern hemisphere, and has heated the sandy plains of Australia and Africa, the air superincumbent on these countries is so rarefied as to rise into the higher regions and thus the colder air, which in that season envelops the northern hemisphere, rushes southward to re-establish the equilibrium of the atmosphere. This current of air is the north-east monsoon of the Indian Sea This explanation is satisfactory, as it is not at variance with the phenomena with which the wind is attended It receives, on the contrary, a strong support from the gradual progress of the wind from south to north For it is evident that, as the rarefaction of the air is first effected in the southern parts of the ocean, the current must first become perceptible there, and only when it continues longer, and increases gradually, is the more distant air called in to supply the deficiency Therefore the north-east monsoon begins near the equator and extends gradually northward to Cape Guardafui and the shores of Arabia

The same principles were applied to explain the origin of the south-west monsoon Along the northern tropic, and on both sides of it, countries are found which form a part of the continent of Asia, and here, too, are large plains, some of which have a sandy soil and are subject to be heated to a great degree when under the influence

of the perpendicular rays of the sun. Under such circumstances a considerable rarefaction of the air must take place, and the consequence is, that the southern air, which is only heated by the oblique rays of the sun, and consequently much colder, flows northward to replace the air which has escaped by rarefaction. We must now observe, that this explanation is not in accordance with the phenomena. If the rarefaction of the air, which is the supposed cause of the wind, takes place near the tropic, it follows, as a matter of course, that the wind must make its first appearance near the tropic. It does not, but it appears to arise, first, in those tracts of the sea which lie near the equator. Further, we should expect that the wind would extend gradually from the place of rarefaction to those parts of the sea which are contiguous to the line. It does not, but it advances from the equator to the tropic, or to the place where, according to the hypothesis, the rarefaction of the air occurs. At Anjengo, as we observed, it is felt more than a month sooner than at Bombay. It may, perhaps, be objected, that the effect takes place immediately after the sun, in its progress to the northern hemisphere, has crossed the equator, and consequently there the wind must first make its appearance. But to this we answer, that the sun at that time must rarefy the air near the line, and that, according to our knowledge of the constitution of our atmosphere, the wind should continue to blow from the north, as at that time the air incumbent on the northern hemisphere, having been deprived of the perpendicular rays of the sun for six months, must certainly be much colder than that of the southern hemisphere, which has been exposed to the sun's full force for half a year. An hypothesis at variance with all the phenomena it attempts to explain cannot be admitted. It would therefore appear that our knowledge of the laws of nature is still too incomplete to afford a satisfactory explanation of the origin of the south-west monsoon. We shall only observe, that the wind closely accompanies the sun in its progress, or rather precedes its march. On the 21st of April the sun has advanced twelve degrees from the equator, and on the

12th of that month the wind invariably sets in at Anjengo. On the 21st of May the perpendicular rays of the sun fall on the parallel of 20° of northern latitude, and on the 15th of that month the wind sets in at Bombay

We pass to the monsoons which prevail in the Indian Sea south of the equator Their southern boundary, as already observed, lies between 12° and 13° S lat, and as on the north they frequently are met with at a distance of one or two degrees north of the equator, their northern boundary may be fixed at 1° N lat In the region confined by these two lines a south-eastern wind prevails when the sun has a northern declination, from April to October, and a north-western when it is in the southern hemisphere, from October to April Here, too, the change of the monsoons takes place during a space of from three to four weeks, at which time the air is in a very unsettled state, and alternately subject to gales, hurricanes, variable winds, and calms

The *south-east* monsoon blows commonly from that quarter, whence its name is derived, but as the long chain of islands, of which Java is the largest, lies in the middle of the region, and extends nearly due east and west, the monsoon takes also that direction in this part of the sea, and hence it is called by some the east monsoon In that part of the Indian Ocean which lies between the northern shores of Australia and the equator, this monsoon blows with great regularity and considerable force, but west of [illegible]a Strait it is frequently weak, and sometimes inter[illegible]ed by other winds It is a remarkable fact, that this monsoon is never attended with heavy and lasting rain, as the others are, though during its prevalence smart showers are rather frequent at many places, and perhaps everywhere But in general the weather is comparatively fair and settled

The *north-west* monsoon prevails from November to the end of April. In the sea between Madagascar and Sunda Strait it varies in direction between north-west and south-west, and is there in general not very regular in strength, except in December and January, when it blows with force. In the Java Sea—as that part of the

Indian Ocean is called which lies north of Java and extends eastward to the island of Timor—and in the Molucca Sea, which lies between Timor on the west and New Guinea on the east, this wind commonly blows from due west, hence it is frequently called the western monsoon. In these seas, and also south of them to the shores of Australia, it is regular, and blows with considerable force. This wind brings the rainy season to all countries to which its influence extends, and though the quantity of rain is not so great as in some countries subject to the south-west monsoon, it is rather abundant even for countries lying between the tropics. These rains appear to fall in greatest abundance on the northern shores of Australia, where the seasons resemble those of Hindustan, as far as their constancy is regarded. For during the months of June, July, August and September not a drop of rain falls, whilst in the other months, especially in December and January, the rains are very heavy though perhaps not quite so heavy as in many places in Hindustan.

The south-east monsoon is considered as a continuation of the trade-wind of the Southern Pacific. There is certainly a great resemblance between them in character, both being serene, and very rarely, if ever, attended with heavy rains. Besides, we know that in the season when this monsoon prevails, the south-east trade-wind extends over the whole breadth of the Pacific to the very shores of Australia and New Guinea. Considering this monsoon as a continuation of the trade-wind, its origin does not require an explanation.

The north-west or west monsoon, however, which in almost all its phenomena differs greatly from the trade-winds, would certainly claim an explanation of its origin, but hitherto no hypothesis has been offered for that purpose. This apparent neglect is partly to be ascribed to the difficulty of the task, and partly to the circumstance that this monsoon was considered to occupy in the Indian Ocean, the place which in the Atlantic and Pacific is taken by the region of calms. Now as in this region western and south-western winds are more

prevalent than others, it was thought that north-west monsoon did not require a particular explanation. But the supposition itself was ill-founded. For in the Atlantic and Pacific the region of calms lies north of the equator, and the west monsoon exercises its influence only on the sea south of the line. The difference between them is also proved by the latest accounts, according to which the region of calms and the west monsoon exist separately in the Pacific. Until within a few years this monsoon appeared only to play a subordinate part among the monsoons. But it now appears to constitute the leading feature, as it has been discovered that it extends into the Pacific, to the very centre of that ocean, or to more than half-way between New Guinea and America. For, as we observed in speaking of the trade-winds, its effects are experienced as far east as the Marquesas Islands. From these islands (140° W. long.) the western monsoon is met with westward to the northern extremity of Madagascar (315° W. long.), so that it blows over one hundred and seventy-five degrees of longitude, or nearly over one-half of the globe. Every one who considers the nature of this monsoon, will be aware, that the principles on which the explanation of the trade-winds rests are quite insufficient to convey an idea of the manner in which the west monsoon originates. That the almost innumerable islands and coral reefs with which the Pacific is beset between the equator and the southern tropic materially contribute to the formation of this monsoon, can hardly be called in question, but in what manner their influence is exercised remains a secret. Here, too, it is evident that there must exist in the atmosphere of our globe a process of nature with the laws of which we are not yet acquainted.

The force with which the monsoons blow is much greater than that of the trade-winds. When in force they blow a moderate gale, and even a fresh gale. In such cases a vessel can hardly carry all its sails, and is obliged to proceed with the upper sails reefed, and sometimes double-reefed. The force of these winds, added to the circumstance that the currents always flow

with the wind and run with great force, render it an extremely tedious and laborious task to work up against them. Frequently it is quite impossible to stem their violence in any way. Nothing can be gained by tacking and hugging the wind close. Many vessels, which have made efforts to force their way against it, have been compelled to give in, and to enter the nearest harbour to wait until a change of the monsoon takes place. Other vessels have been obliged to change their course, and to reach their place of destination by following a different track, wide of the straight route, and thus avoiding the monsoon. When vessels sailing from Europe to China are by some accident prevented from reaching the region of the monsoons in the favourable season, they find themselves reduced to the alternative either to remain in harbour for four or five months, or to leave the direct track for another along which the wind is more favourable to their progress. Thus a vessel bound to Canton, and arriving in Sunda Strait in the beginning of December, cannot accomplish its voyage by running north and north-east through the Chinese Sea, as in that and the following month the north-east monsoon is too strong, and opposes the progress of the vessel with too great violence. She must, therefore, take another route, where the obstacles are less powerful. The Straits of Macassar, between Borneo and Celebes, offer such a route, as it lies from south to north. Having passed through it, the vessel finds a northern wind in the Celebes Sea, and must pass eastward into the Pacific, leaving the island of Sanguir on the right. But the Straits of Macassar are only practicable for such vessels to the end of December or the beginning of January. Later in the season northern winds prevail, and are attended with strong currents and a very rough sea. Then the vessel must sail farther to the east, pass round the southern extremities of Celebes, and hence direct its course through the Molucca Sea towards the north-western extremity of New Guinea, near which it passes through Pitt's Strait or Dampier's Strait into the Pacific. This route is very dangerous on account of the rocky

islets which are dispersed in great number over this part of the Indian Ocean, and it is only open to the middle or, at the utmost, to the end of February. But as about the same time the strong northern winds and southern currents in Macassar Straits abate, the vessel may then take the route through that strait. All the vessels which are compelled to follow these tracks must enter the Pacific, and proceed in it as far as 135° E. long., whence they direct their course to the Chinese Sea, and enter it by the Straits of Formosa.

But though the monsoons to vessels which miss the right season, render the voyages long, tedious, and laborious, they greatly promote those of ships that arrive in these seas at the right period, and more than other winds. It is chiefly by the assistance of the north-east and north-west monsoons that the voyages of mercantile vessels bound from Canton to England are accomplished in the comparatively short period of 120 days, or four months, as the space they have to traverse does not fall short of 14,000 miles so that the progress of the vessel is nearly 120 miles per day. The advantages which vessels sailing from Europe to Calcutta, Singapore, and Canton, derive from the south-west monsoon, are nearly equal, though their voyages are considerably longer, which is to be ascribed to causes not connected with the monsoons.

Great as the advantages are which the trade and navigation of the Europeans derive from the monsoons, they are but very small when put into comparison with those which are imparted by them to the inhabitants of those countries which are placed within the reach of these winds. Their intercourse by sea is very easy and certain at the same time. With one monsoon their vessels leave their country, and with the other return to their homes. Chinese vessels from Canton and other places in the neighbourhood leave their ports in January, when the north-east monsoon is in force, and after a voyage of twelve or fifteen days they arrive at Singapore, where in a couple of months they sell their cargoes, and after having settled their affairs they return home, towards the

end of April, with the south-west monsoon, with what they have bought at Singapore for the Chinese market. The return voyage does not take more than twelve or fifteen days, for on both voyages they have continually a fair wind. The construction of their vessels is adapted to the strength of the monsoon, and they do not carry more sail than the wind permits. To these circumstances probably it is to be attributed that among the vessels of the natives of those countries the shipwrecks are not more numerous than in other parts of the ocean, though the Chinese Sea is much dreaded by European seamen on account of its numerous rocky islets.

We find that by nature the whole ocean is divided into three regions, which are under the influence of the trade-winds, of the monsoons, or of variable winds. It is here perhaps not out of place to take a rapid view of the advantages navigation derives from the prevailing winds of each of these regions, by inquiring in which of them navigation has been earliest practised. We shall first mention the fact that even at present those nations which carry on navigation on a large scale, are found to inhabit those countries only which surround the region of the variable winds in the Northern Atlantic, and those which lie within the reach of the monsoons. All other nations have either no seafaring vessels at all, or only such a small number as not to be taken into account in a general view of the subject.

When we consider the peculiar nature of the trade-winds, we must be directly aware that no portions of the ocean are less favourable to the first attempts of navigation than those which are governed by these winds. With their aid, adventurers may easily get far from their countries, but they preclude the possibility of their returning. Under such circumstances, it can never have entered the head of a man to make the attempt of navigating the sea at large. It is therefore probable that the region of the trade-winds was never navigated until it was entered by seamen who had acquired skill in turning to account every kind of wind, by a long practice in the region of the variable winds. Such seamen alone could

muster courage to enter on so arduous an enterprise, from the difficulties of which they could only disengage themselves by their superior skill in managing a ship. We may here remind the reader, as a fact in support of this opinion, that the Portuguese, in their ever-memorable first voyage round the Cape of Good Hope, never met with a vessel larger than a moderate fishing-boat on the western shores of Africa, nor on the eastern until they arrived at the town of Mozambique, which is built, as it were, at the very entrance of the region of the monsoons; for the north-east monsoon extends far southward into the strait which separates the island of Madagascar from the African continent. In the harbour of Mozambique, however, the Portuguese found seafaring vessels, and pilots who conducted their vessels through the region of the monsoons to the shores of Hindustan.

The first attempts at navigating the region of the variable winds must certainly have been beset with great difficulties, and their progress in navigation must have been very slow. We shall not dwell on the great skill it required to meet promptly all the changes of the wind, both in direction and strength, which skill could only be acquired in a period of many generations. A much longer period must have passed before long voyages were undertaken. It certainly soon became evident that it was very possible to accomplish long voyages, but still there remained a doubt, if not respecting their issue, certainly respecting their duration. This uncertainty must for a long time have kept the minds of the adventurous seamen in suspense, and limited their voyages to comparatively short distances. How many centuries may have passed before, aided by circumstances and successful attempts, their skill and courage increased to such a pitch as to enable them to extend their voyages farther and farther, until at last they succeeded in subjecting the whole region of the variable winds to their power, and then found themselves sufficiently prepared to contend with the trade-winds!

The seamen of the region of the monsoon had not to pass through this long course of preparatory training.

When they had observed for a few years the regularity with which the changes of the seasons and the winds followed one another, they soon comprehended that there was no danger of being cast away from their homes, even in long voyages. The first adventurers abandoned themselves to the winds and currents, without caring how far from their homes they were carried by them, being convinced that, after a few weeks or months, another wind would spring up which would safely convey them back to the places whence they had departed. There can therefore be hardly any doubt that navigation, on a very large scale, was practised in these seas at a very remote period, and it is even not improbable that from the Arabian Sea it was introduced into the Persian Gulf, where, according to the statement of Herodotus, the Phœnicians originally resided, and that, at the time of their migration, the art of navigation was introduced into the Mediterranean, whence it spread over the regions of the variable winds of the Atlantic, where it has attained the highest degree of perfection. The opinion that navigation is of very ancient date in the region of the monsoons is supported by two facts: by the high degree of civilization the inhabitants of some of the countries which are adjacent to the seas swayed by these winds have attained, and by the great extent to which navigation has always been practised, and is still, in these seas. The inhabitants of China and Hindustan are certainly acquainted with all the arts of civilized life to a great degree, and their history shows that they have been in possession of them for a time out of memory. It may be objected that other nations similarly situated, as the Malays, have stopped at a comparatively low stage of civilization. This must be ascribed to other circumstances. There are no seas which abound more in fish than the regions of the monsoons, especially that portion of it which lies south of the equator, and it affords to the Malays as plentiful a subsistence as agriculture would do, and that with less than half the labour which the latter would require. Besides, they are so situated that they can with the greatest ease communicate with those countries which, by their greater

degree of civilization, can furnish them with all those necessaries of life they are in need of, and which they cannot procure in their own country. They go to these countries in their own vessels, for if we except the civilized countries of China and Hindustan, we find that the larger portion of the population of the countries subject to the monsoons is composed of fishermen and seamen and their vessels are met with everywhere as far as the monsoons extend. This is the reason why the number of European vessels engaged in the trade of these parts is so limited. These vessels are only employed in supplying a few places, where depots of European merchandise have been established, with those goods which are in demand among the inhabitants of the islands, but they do not convey them to the places where they are consumed. Native vessels, in considerable number, arrive annually at such places as Singapore, Batavia, and Surabaya, to dispose there of the produce of their countries, and to buy foreign goods, which they afterwards disperse over all the islands of the Indian Archipelago and the neighbouring countries. But though the monsoons greatly facilitate navigation within the limits of the region in which they prevail, they render their seamen unfit for extending navigation beyond the boundaries of the region. They have no opportunity of acquiring the skill and courage which are required to contend with the dangers and difficulties to be encountered in the regions of the variable winds and of the trade-winds. We must therefore consider the introduction of navigation into the Mediterranean by the Phœnicians as an event which has promoted, more than any other recorded in history, the civilization of the whole human race, and changed the face of the globe.

We have mentioned the abundance of fish found in those seas which are swept by the monsoons. The quantity and variety of fish, shell-fish, mollusca, and crustacea, which are met with in these seas are almost incredible. We know this fact with certainty respecting the seas which extend from Sumatra eastward to New Guinea, but it would appear that fish is as abundant to the east of

the last-mentioned island as to the west of it We must at least adopt such an opinion when we find that the inhabitants of the islands lying between New Guinea and the Viji group show their ingenuity, and the progress they have made in the arts of civilized life, in nothing so distinctly as in the construction and outfit of their boats To what an extent fishery is carried on in these seas may be inferred from the fact that as many as four hundred fishing-boats have been counted at once from the deck of a European vessel in the sea which surrounds the southern shores of China We are very imperfectly acquainted with the kinds of fish which frequent these seas, but we know that, besides the enormous quantity of fish which is consumed by the inhabitants, who prefer them to all other food, there are several kinds which are cured for foreign markets Among them the sea-slug, or beche-de-mer, is by far the most important It is conveyed in a dried state to China, where it is considered a dainty and fetches a very high price If we can place any reliance on the information which occurs only occasionally in books of travels, we must be persuaded that the number of fishermen who are engaged in this branch of fishery, between the shores of China and those of Australia, is greater than that of those who derive their subsistence from the cod-fishery on the banks of Newfoundland and along the coasts of Norway The great abundance of these sea-slugs, and the ready market which is found for them, has given rise to a tribe of itinerant fishermen called the Bajoos, who have their station along the eastern and north-western coasts of Borneo They have no other abode but their boats, in which they have their families, and in which they pass their whole lives In these boats, which are of about five tons burden, they shift to leeward, from island to island, with the variation of the monsoons Their occupation is limited to the catching of sea-slugs, and to curing them for the market

It is a well known fact that in all countries the climate is modified to a smaller or greater degree by the prevailing winds, but the monsoons alone appear to possess the power of infringing that order of nature, which in other

countries similarly situated between the tropics is considered as immutable. In all intertropical countries, as it is known, the year is divided between the dry and the rainy seasons The rains commonly begin when the sun enters the hemisphere in which the country is situated, at some places somewhat sooner and at others later, and they last until the sun has again returned to the equator and is passing into the opposite hemisphere Some countries have two rainy seasons, each of them falling in the time when the sun approaches the zenith of the place, either receding from the equator or approaching it. These two rainy seasons must, however, be considered only as portions of one rainy season, which is divided by an interval of a few weeks of fair weather into two parts When the sun is in the other hemisphere most of these countries have not a drop of rain for six months. It is evident that in all these countries the seasons are dependent on the position of the sun, and that the heat produced by the sun in the atmosphere is the sole cause of these changes This order of the seasons is considered in these countries as an immutable law of nature In countries situated in seas where the monsoons predominate there are also two seasons, the dry and the wet, but they do not depend on the position of the sun, they are regulated by the monsoons alone Thus we find that when the sun is in the southern hemisphere, the coast of Coromandel, though situated in the northern hemisphere, is drenched with rain by the north-east monsoon, and the rains are most abundant when the sun's perpendicular rays fall on the countries situated in the vicinity of the southern tropic Between the rains brought on by the monsoons and those which are to be considered as dependent on the march of the sun, there is another remarkable difference The rains of the last description extend over the whole country uniformly, and when there is a difference in their quantity, it commonly may be accounted for by local circumstances But the rains which attend the monsoons do not extend uniformly over the whole country, but only over those parts which lie near the coasts on which they blow. They cer-

tainly, in many cases, advance to a considerable distance inland, but at the same time they diminish in quantity in proportion as they recede from the shore. All these circumstances impart to the climate of these countries a quite peculiar cast. It happens frequently that one part of the country is drenched with rain, whilst not a drop falls in another part, that one tract suffers by the superabundance of moisture, whilst another is burned up by an extreme dryness of the atmosphere and a powerful sun. Thus the western shores of the peninsula of Hindustan have very heavy and almost continual rains during the south-west monsoon, which wind brings only a few very slight showers to the eastern shores of that country. On the contrary, during the north-east monsoon the rains are abundant on the eastern shores, whilst not a drop of rain moistens the western coast. Another point which deserves to be noticed is the difference in the quantity of rain, which is great in countries exposed to the immediate effects of the monsoon and situated at no great distance from each other.

We have before noticed the different quantities of rain which fell during the south-west monsoon at Tellichery, Bombay, Calcutta, Benares, and Aracan. It is not easy to assign a cause for this difference. It would however seem, that two circumstances are most powerful in bringing about this effect, the position of the coast with respect to the direction of the wind, and the existence or absence of high and steep mountains in the vicinity of the shores. When the monsoon blows on a coast-line under a right angle, and is arrested in its progress by high and precipitous mountain-masses all the moisture with which it is loaded, or which it generates on coming into contact with the air of the land, is discharged on a tract of comparatively small extent, and in such places the quantity of rain is immense, as is the case with Chittagong and Aracan. The coast of Malabar receives the blasts of the winds under an angle somewhat less than a right one, and though the Gaut Mountains are not far distant from the shores, the quantity of rain is considerably less, though still very abundant when compared

with other parts of the country. The delta of the Ganges, and the coast opposite the town of Bombay, present to the sea a front line which forms a much lesser angle with the direction of the wind than the coast of Malabar. Accordingly we find that the quantity of rain which falls on the delta of the Ganges amounts to hardly one-third of that which descends on the low country of Aracan, and at Bombay only half the quantity of rain is experienced which drenches Malabar, though opposite Bombay the mountain-masses advance as near to the sea as at Tellicherry.

The effects of the monsoons in changing the seasons are nowhere better exemplified than in the island of Sumatra. This island is traversed by the equator nearly in its middle. The northern portion therefore lies within the region of the north-east and south-west monsoons, whilst the southern half is exposed to the effects of the north-west and south-east monsoons. This produces different seasons, not, as in other parts of India, on coasts which have a different position as regards the points of the compass, but even on coasts which lie in the same direction and are contiguous to each other. The south-western coast of Sumatra lies when the sun is in the southern hemisphere under the influence of the north-east monsoon north of the equator, but the southern half is within the reach of the north-west monsoon. The north-east monsoon passes over the low isthmus of Krau, which connects the Malay peninsula with the continent of Asia, but in arriving at Point Acheen, the most northern point of Sumatra, its direction is influenced by the position of the island and its mountain ranges, and is inflected towards the south, so that along the south-western coast it blows from the north-west. During its prevalence that portion of Sumatra has its dry and fair season. But the north-west monsoon, which at this season prevails along the southern half of the south-western coast, empties its abundant rains on its shores. Thus apparently the same wind brings to the northern district fair weather and to the southern rain, forming a very striking irregularity. During the opposite season,

when the sun has a northern declination, the south-western monsoon prevails along the northern coasts, and brings rain, whilst the southern parts enjoy fine weather, brought on by the south-eastern monsoon On the north-eastern shores of Sumatra the seasons are not well marked When the sun is in the southern hemisphere the north-east monsoon, as it appears, prevails along the whole extent of this coast, but within the Straits of Malacca it is very irregular, being frequently interrupted by other winds or calms, so that it entirely loses its character, and the same may be said of the south-west monsoon, which predominates in the opposite season The force of the monsoons, it appears, is broken by the mountain ranges which enclose the strait on both sides. To these circumstances also is probably to be ascribed the fact of rain occurring all the year round on both sides of the Strait of Malacca, it is, however, not abundant, though frequent The most heavy showers fall between the end of September and the end of November, that is, in those months when the south-west monsoon changes into a north-east monsoon But the southern part of the north-eastern coast of Sumatra has regular dry and wet season The rains are brought to it by the north-east monsoon, which in these parts commonly advances to a distance of two or three degrees south of the equator The dry season is brought on by the south-east monsoon.

The Island of Borneo is also traversed by the equator nearly in its middle, and offers another deviation from the common course of the seasons, but of a different description Though this island is assailed by all four monsoons, its two seasons fall on the same months of the year all over the island, which does not happen in any other country of similar extent within the reach of the monsoons. This apparent irregularity is to be ascribed to the circumstance, that the rainy season on the north-western and north-eastern coast is attended by the north-east monsoon, as in Coromandel and Cochin China. As in the same period of the year the west or north-

west monsoon prevails on the southern districts of the island, and drenches them with rain, the whole of the Island of Borneo has its rainy season when the sun is in the southern hemisphere, from October to April, and its fair season in the other half of the year

The setting-in of the south-west monsoon and of the rainy season is attended with very remarkable phenomena on the coast of Malabar In the month of February the low country between the sea and the base of the Ghaut Mountains becomes excessively hot, though the sun is then in the southern hemisphere, and far from the equator After some days the air begins to be charged with vapours and exhalations so dense that it is difficult to distinguish an object at a distance of a few miles which curious process may then be viewed from the top of the mountains, where the cold is scarcely supportable The heat increasing during the months of March and April, a prodigious quantity of aerial moisture is collected, which remains day and night in a floating state, sometimes ascending nearly to the top of the mountains, where it is checked by the cold, and then descending is again immediately rarefied and becomes vapour before it can reach the earth In this state of buoyant perturbation the atmosphere continues until the setting-in of the monsoon, which is attended by loud claps of thunder and violent gusts of wind By their intervention the vapours are condensed into rain, but not at once, for during the first two months the rains are by no means excessive They become so in June, and are attended by the most violent squalls of wind, during the prevalence of which all trade is suspended, and ships disappear entirely from the coast, all insurances being void until the end of September, when the monsoon moderates, and the rain abates From this account it is evident that the rains brought by the monsoons are not produced by condensation of the moisture which the wind has collected in passing over a large extent of sea, but that its elements are generated on the land itself, and that they rest suspended in the hot air until condensed by the monsoon,

and converted into rain This opinion receives a strong support from the fact that navigators traversing this sea during the south-west monsoon usually enjoy moderate and fine weather, with a cloudless sky overhead and a clear horizon, as long as they remain at a certain distance from the shores of Malabar

SECTION X.—PLAINS AND DESERTS

VAST plains possess but few attractions: they excite little interest, and few visit them for pleasure; whilst mountainous districts are frequently crowded by travellers from the remotest countries. What hosts of visitors are continually met with in almost every valley of the Alps, whilst a person may traverse the plains of Hungary, from one extremity to the other, without meeting a person whose residence is not in the next village or town. This preference is owing to the scenery exhibited; to the variety, beauty, and grandeur of the objects presented by mountain regions. The continual alternation of hills and dales, of wooded slopes, naked precipices, craggy peaks, rugged rocks, limpid streams, fertile glens, grassy pastures, cultivated fields, and groves of fruit trees, together with glaciers and snow-capped mountains, are found within small distances of each other, so that all these objects may be seen in the space of a day or little more. The eye and the attention of the spectator are kept in uninterrupted activity. New objects perpetually crowd on his attention, impressing the mind with new ideas. He feels his mind and his body excited to the highest degree. Very different are the impressions experienced by the traveller who traverses a plain. If its surface is not level, but diversified by low hills, it presents from time to time some object to attract attention, and when human industry has been applied with success to the cultivation of the country, he will feel considerable interest, diffusing a certain degree of pleasure over his feelings. In viewing an extensive level plain for the first time, and from a height considerably above it, the first impression is rather grand from its

extent, especially when the traveller has been for many days in valleys and between high mountain ranges. When the Plain of Lombardy is first seen from the heights of the Alps, it presents itself to the eye like a boundless garden, and the impression is pleasing. But in travelling over it all interest begins to die away, and the continual sameness of the scenery rapidly becomes tiresome. In the Plain of Lombardy, and similar places, some interest is created by the sight of the monuments of the successful industry of man, the towns, villages, plantations, and well-cultivated fields; but where such objects are wanting, the tiresomeness passes by degrees into listlessness, which, when continued for any length of time, produces complete exhaustion. A visit to a mountain region may be compared to a succession of joyful occurrences; a visit to hilly tracts, to the events of common life; and a journey over an extensive uncultivated plain, to the feelings excited in an active man, used to constant occupation, by a continuance of forced inactivity, or to those of a man accustomed to rambling, and now undergoing the punishment of solitary imprisonment.

Though large level plains are avoided by persons who travel only for pleasure, they yet deserve to be noticed as one of the prominent features of the globe: Importance is attached to them, partly from their extent, and partly from their capacity of supporting a numerous population. The last quality, indeed, belongs only to some of them in any eminent degree, whilst others are possessed of so few resources in this respect, that they have justly been named deserts or wildernesses. In the great plain of northern China the population is so closely packed, that it has been thought necessary to introduce some usages, and to enact laws by which the most common actions of man are regulated, merely for the purpose of preventing persons from coming into too close a contact to one another; whilst in the Sahara a traveller may continue his progress for days or weeks without seeing a human face. The Plain of Lombardy is covered with towns, villages, and plantations, whilst in the Llanos of South

America the isolated dwellings of the herdsmen are many miles distant from each other.

If the importance of plains were limited to their capacity of furnishing subsistence to man, they would be chiefly objects for the attention of those who occupy themselves with statistics; but they exhibit the greatest variety in the intellectual and moral development of the human race. The inhabitants of two widely-distant mountain ranges, situated in different zones, resemble each other far more in character, ideas, occupations, manners, and customs than those of two large plains similarly situated. Many points of strict resemblance exist between the inhabitants of the Alpine valleys, which are from three thousand to five thousand feet, and those of the Himalaya Mountains, occupying slopes from five thousand to seven thousand feet above the sea-level, and both differ but slightly from the tenants of the Andes, who reside near the equator in mountain recesses from seven thousand to eight thousand feet above the sea. This cannot be a matter of surprise, when it is considered that all these mountaineers inhabit tracts which resemble each other in climate, fertility, productions and scenery—circumstances which, more than all others, are operative in forming characters, opinions, and usages. At the respective elevations above stated, the climate of these regions cannot differ greatly. Valleys in general present less variety of soil than exists in a flat country. Their soil is formed partly by gravel, which by abrasion has been detached from rocks, and partly by earthy matter, which has been washed down by rains. There may exist a difference in the proportion of these constituent parts, but this difference is not great. As the great mountain ranges consist either of the same or similar kinds of rocks, the fertility of the soil does not differ materially. Some difference may certainly be found in two valleys not far from one another, but not enough to be taken into account in a general view of the subject; and it may be taken as an established fact, that the valleys of mountain ranges do not exhibit any considerable difference in the fertility of their soils. Where the climate

and soil of two tracts resemble each other, it is found that the vegetable productions are similar, and that nearly the same degree of industry and care is required to produce them. The same observation applies to domestic animals. The scenery probably exhibits a greater difference than what exists in the climate, soil, and productions, in the three above-mentioned mountain ranges, and must in some degree affect the mental development of their inhabitants, though these differences, few in proportion to those which are found between the inhabitants of plains, may be partly accounted for by variations in the religion, in the race from which the mountaineers have sprung, and still more from the political state of the bordering countries. As, for instance, all mountaineers believe that they are superior in courage and enterprise to their neighbours inhabiting and cultivating the lower country, they are inclined to levy contributions on them, and to keep them in a state of subjection, when their attempts are not checked by a regular and effective government. The Swiss did so, during the middle ages in those portions of the Plain of Lombardy which lie close to their mountains, and the Scotch Highlanders of the Grampians levied black mail from the Lowlands. The Abors, inhabiting the Himalaya Mountains north of Assam, and the Singfos, living on the mountains south of the Brahmapootra, levied contributions from the Assamese as long as the government of that country was in a distracted state, and did not abandon their claims until compelled by the British authorities.

How differently are the inhabitants of great plains affected by their position! Two plains can only influence the formation of the character of their inhabitants to an equal extent, and effect a certain similarity of ideas and customs, when they have a similar soil and climate. But their soil exhibits all the different shades which lie between the rich alluvial deposits of the Chinese plains and the bare, smooth sandstones, or the loose sand, of the Sahara. Their variety in this respect is beyond enumeration. Hardly less different is their climate. It is not only affected by their geographical position in latitude, but frequently also by their longitude. Another

diversity in the climate is the effect of their elevation above the sea-level. A plain situated in the torrid zone, when raised by the subjacent mountain-masses to an elevation of 5000 or 6000 feet above the sea, is as it were transplanted to the temperate zone, and its productions are so changed that this alone must greatly surprise a person not familiar with the fact. All these varieties of climate and soil impress lasting effects on the character of the inhabitants, and promote or retard their mental development. One of the most striking instances of these effects is exhibited in the different character of the Mongols and Chinese. The Mongols are proud, frank in their manners, independent in their behaviour, courageous, disregarding conventional practices, religions, superstitious, idle, impatient of control, inclined to change, active but incapable of continued labour, and rebellious against established order if contrary to their inclinations. The Chinese are simple, submissive, crouching, cautious, cowardly, tenacious of social ceremonies, strict observers of conventional manners, freethinkers, regardless of religious tenets but adhering to the ceremonies of their creed, laborious, industrious, obedient to laws and government. There are hardly to be found on the whole surface of the globe two nations which differ more from each other than the Chinese and Mongols, yet they belong to the same race, and live in countries which border on each other. But the plains in which the Mongols wander are at an average 3000 feet above the sea-level, and their surface is covered with gravel, sand, and stones, whilst the Chinese cultivate an alluvial plain, more fertile than any other portion of the globe, and but little elevated above the sea. Though subject to the same authority, they are governed by distinct laws, and an administration which is organised on different principles.

It is certainly interesting to trace the connexion between the physical constitution of a country and the mental development of its inhabitants, and such is the purpose of the following essays on the Desert of the Sahara, the Selva of the Amazonas, the Pampas and Llanos of South America.

Section XI.—The Sahara.

The Sahara, whose full name is Sahara-bela-ma, "the Desert without Water," sometimes also called the Bahar-bela-ma, "the Ocean without Water," is a region of immense extent, occupying the central parts of Northern Africa. On the west it reaches the very shores of the Atlantic Ocean, between 15° and 30° N. lat., and hence it extends eastward nearly across the whole continent of Africa, being separated from the Red Sea only by the valley of the Nile and the rocky country beyond it. Its length in this direction is not less than 2650 miles. Its width is various. The widest part is between 5° and 10° E. long., where the desert occupies nearly eighteen degrees of latitude, or about 1200 miles. But farther to the east it narrows at one place to ten degrees of latitude, or 700 miles. It is certain that we do not overrate its extent by assigning it an area of 2,500,000 square miles, which is more than two-thirds of the area of Europe.

This immense region enjoys a smaller share of the gifts of nature than any other known portion of the globe. Soil and climate are unfavourable to vegetation, and consequently afford very sparingly the means of sustaining animal life. It is, however, not uniform in this respect. Near 15° E. long. the desert is crossed by a more favoured tract, in which Fezzan is situated, a district of which the soil at several places consists of clay capable of producing a kind of millet, and where groves of date-trees are numerous. Between Fezzan and Lake Tchad several stony ridges occur, at the bases of which wells are found, and in their neighbourhood are some extensive plantations of date-trees, with pasture-

grounds for cattle But between them lie tracts, composed of loose sand in which the camels sink nearly knee-deep, and quite destitute of vegetation No water can be obtained in them. In approaching Lake Tchad the sandy soil is interspersed with clumps of grass, and here and there with low bushes, which are soon succeeded by trees, increasing in number and size until the town of Lari is reached, situated at a short distance from Lake Tchad

By this tract the desert is divided into two unequal portions, the eastern and smaller called the *Lybian Desert;* the western and larger the *Sahce* On both regions nature has strongly impressed all the characteristics of sterility, but still there is some difference in soil and climate The Lybian Desert is superior in both respects Its surface, in most places, is not covered with sand, but is formed of a hard sandstone rock with horizontal strata on which the traveller may not find a single grain of sand for several days The rocks are as smooth and level as a bowling green, not exhibiting the least furrow or depression of the surface for hundreds of miles Nothing is to be seen but the hard pavement under foot, and the cloudless sky overhead At last the scene changes. The sandstone is succeeded by gravel, frequently interspersed with rounded pebbles The surface continues to be flat, but is frequently furrowed by ravines and glens, sinking sometimes to thirty feet below the general level, and in these depressions a few bushes are met with Round these bushes the finer sand, brought by the easterly winds, frequently collects, so as to form small sand-hills Some portions of these gravelly plains are impregnated with salt, and there are spots which are covered with incrustations of that mineral, so as to appear as though they had a slight covering of ice At a few places there are short ridges of low limestone hills, especially in the northern parts, one or two of which rise so high as to be called mountains. But these tracts are likewise barren All these plains and ridges bear the sign of utter sterility, and exhibit hardly any trace of vegetation However, there occur in the plains oc-

casionally, but at great distances from each other, depressions which sink below the thick stratum of sandstone constituting the general surface, from under which the small quantity of water deposited finds its way to the surface of the depressions in the form of springs, being at some places so copious as to be used for the purpose of irrigating the adjacent lands The soil, though mostly composed of sand, contains some earthy matter, which renders it in some measure fruitful. On the fields rice and millet are cultivated, and there are groves of date-trees and doum-trees, both bearing edible fruit, which is gathered with care Other trees, especially acacias, and yews, occur occasionally The inhabitants keep sheep, goats, and fowls These depressions are called oases, and some of them are of considerable extent The largest is about three days' journey from the banks of the Nile, and is called Wadi-el-Khargeh It is nearly a hundred miles in length from south to north, with a width varying between one and fifteen miles Several other oases, but of much smaller extent, occur in the desert at a distance of between three and five days' journey from the banks of the Nile They are less frequent in the northern districts of the Lybian Desert, but a considerable number of them, according to the account of the natives occur in the southern parts of it That portion of the desert which extends west of the Valley of the Nile, participates in the showers of rain which fall in Upper Egypt and Nubia, and the southern are reached by the last and slight offsets of the tropical rains, which drench the countries south of 15° N. lat The northern parts have no rain at all, as the table-land of Barca prevents the rains prevailing in the Mediterranean from penetrating so far inland.

The oases which lie in the vicinity of Egypt are inhabited by Arabs, who do not differ from the Arabs settled in the Valley of the Nile, and who divide their time between agricultural pursuits and the care of their plantations The southern part of the desert, as also the tract lying along the road leading from Fezzan to Lake Tchad, is inhabited by the Tibboos, one of the

native nations of Africa. In some of their features they resemble the negroes. Their colour is not uniform. In some it is quite black, but many have copper-coloured faces. They are slim and well made, have high cheek-bones, the nose sometimes flat like that of the negro, and sometimes aquiline. Their mouth is in general large, but their teeth fine. Their lips are frequently formed like those of Europeans, their eyes are expressive, and their hair though curled not woolly. The females are especially distinguished by a light and elegant form, and in their walk and erect manner of carrying themselves are very striking. Their feet and ankles are delicately formed, and not loaded with a mass of brass or iron, as is the practice in other parts of northern Africa, but have merely a light anklet of polished silver or copper, sufficient to show their jetty skin to more advantage, and they also wear neat red slippers. The country which the Tibboos inhabit is the best portion of the Lybian Desert, for not only is the number of oases much greater there than anywhere else, but there are large tracts between them, partially clothed with bushes, which afford pasture for camels, and at some places grass springs up abundantly during the rains, affording them the means of keeping herds of cattle.

It is certainly interesting, and the more so because it is unexpected, to find in the centre of Africa a nation which has attained the highest degree of civilization possible under the circumstances in which it is placed. Poor people, it is said, are more economical than rich ones, and this is certainly true when applied to nations. A people inhabiting a sterile country always direct the efforts of their industry to making the most of its slender productive powers, and manage to live as comfortably and contentedly on its produce as possible. Nothing that can be used as food for man, or be applied to feed domestic animals, is overlooked or neglected. Where the soil, though very indifferent, is strong enough to bear and bring to maturity their only grain, the *gussub*, a species of millet, the Tibboos do not spare labour and care to attain the highest degree of cultivation the nature

of the country admits. Where their pasture-grounds are covered with grass, though commonly of a coarse kind, they keep horses, cattle, sheep, or goats to the utmost limits of the produce. Those tracts which do not produce grass, but are overgrown with bushes and thorny plants, are used as pasturage for camels. As such grounds are more numerous and by far more extensive than those which can be sown or depastured by horses and cattle, camels constitute the principal riches of the nation. Some tribes have more than five thousand of these animals. On their milk they live for six months in the year, and for the remainder manage to supply their wants by the produce of their gussub fields. Though the soil is naturally unproductive of plants which can be converted into clothing, they have succeeded in rearing cotton at a few places, but the produce is not adequate to the consumption. Hence they are obliged to buy such stuffs from the cafilas or caravans which pass through their territories, paying for them partly with horses and *maherhies* or swift-footed camels. These camels are so swift that they can perform from eight to nine miles an hour, and so strong, that they will continue at this rate for twenty hours together. These fetch a high price. As however the number of horses and maherhies they have to dispose of is not sufficient to procure all the articles they are in want of, they add such other articles as they obtain by chasing those wild animals which are found in their vicinity, the ostriches and gazelles. For the skins and feathers of the ostrich, and the dry meat of the gazelle, they find a ready sale in the encampments of the cafilas which traverse their country.

In a hot country like that inhabited by the Tibboos there can be no more evident proof of the progress of civilization than that which is afforded by the wearing of dresses. As long as men go naked they are savages in their minds and in their manners. As soon as they put on a dress, they invest as it were their minds with a great number of feelings which before that period were quite foreign to them, with the feelings of propriety, of de-

cency, of modesty, of respect for other people, and of cleanliness. They humanize as it were their minds, and thus they rise in the scale of the human race Capt Lyon in his travels in Northern Africa has given a description of the costume of the Tibboos, and added a drawing. It must not be expected that they are elegant and conformable to our taste, but they are certainly decent, and may be considered rather as cumbersome when the climate is considered in which these people live.

Savages live entirely in the air or under the shelter of some branches of trees heaped together on the side whence the wind blows, civilized people erect dwellings. The climate must decide on its form and strength A hut in the country of the Tibboos gives as much shelter as a brick-built house in England The villages of the Tibboos are very regularly built in a square, with a space left on the north and south faces of the quadrangle for the use of cattle The huts are entirely of mats, which exclude the sun, yet admit both the light and the air The interior of these habitations is singularly neat clean wooden bowls for the preservation of milk, each with a cover of basket-work, are hung against their walls

It would appear that the Tibboos, such as they are described, must enjoy, if not the plenty, at least the content which is connected with a pastoral life But unhappily they are always kept in a state of uneasiness by the enemies who surround them, and who frequently make incursions into their country to capture young persons of both sexes, whom they carry away and sell as slaves It does not appear that the Tibboos are inferior in courage or activity to their enemies, the Arabs and Tuaricks, but these two nations owe their superiority to the use of fire-arms, of which the Tibboos have so great a dread that they cannot acquire courage to touch them. "Five or six of them," says Denham, "will go round and round a tree where an Arab has laid down his gun for a minute, stepping on tiptoe as if afraid of disturbing it, talking to each other in a whisper as if

the gun could understand their exclamations." Their own arms, spears and daggers, they manage with remarkable dexterity, skill, and effect But as, on account of their agricultural pursuits, they live mostly in fixed abodes, and do not, like their neighbours, lead an exclusively nomadic life, they have not attained that hardiness of character and contempt of danger, nor those habits of depredation, which signalize roving tribes.

The *Sahel*, or that part of the great desert which lies west of the road leading from Fezzan to Lari, contains only comparatively narrow districts along its northern border, which skirts the base of Mount Atlas, and along its southern limit, where it is contiguous with the hilly regions included in Sudan or the land of the blacks, in which tracts of soil, adapted to cultivation, alternate with others whose sandy surface is frequently without any trace of vegetation All the remainder of the country is quite unfit for any kind of agricultural or horticultural pursuits It is probable that in the vicinity of Mount Atlas some oases occur with groves of date-trees, and in which some kinds of millet are cultivated, but such spots are rather to be considered as appendages of the countries lying farther north than as parts of the Sahel. The soil of this desert is far from being uniform. In many tracts of great extent, a hundred miles in length and width, a fine loose sand covers the surface, on which low ridges are heaped up resembling the waves of an agitated sea. This sand, however, insensibly passes into a coarse gravel, which affords a firm footing, but commonly is as destitute of vegetation as the sand. At some places this uniformity is broken by the banks of loose stones or rocks, and at a few places hills of moderate elevation afford some variety to the view. Some of them consist of sand, and are subject to be changed in size and form by the wind, and others are composed of compact sandstone or other rocks. As this soil prevails generally over the desert and is completely destitute of vegetation of any kind, except here and there a few hardy shrubs, not affording food to any animal but the camel, it impresses on this region the stamp of utter

sterility, and presents the image of complete desolation. But there are also several tracts whose gravelly soil preserves as much moisture the whole year round as is required for the growth of bushes of various kinds, and after the rains a kind of grass springs up in the spaces between these bushes There the inhabitants of the desert find pasture for their herds of camels, horses, cattle, sheep, and goats Though some of these tracts are of considerable extent, their scanty vegetation can only support a moderate number of animals, and consequently are not fitted to support a large population, so as to form a numerous community The inhabitants are therefore divided into a number of small tribes, which frequently, from the want of a sufficient supply of the first necessaries of life, find themselves compelled to take them by force from their neighbours, and thus contract those predatory habits which are more prevalent among them than in any other nation on the globe

Though even the best soil of the Sahel is but of an indifferent description, many of the tracts where it occurs would be fit for the cultivation of some of those grains which grow in lighter soils, as for instance millet, if nature had added to this gift a common share of rain and dew, or favoured it with an abundant fall of snow. There are numerous tracts, even in Europe, which would be as little fit for producing grain or potatoes, if nature had not provided for their fertilization by an abundance of atmospheric moisture Snow of course never occurs in so hot a country as the Sahel, and the rains, which are so excessive in almost all those regions which lie between the tropics, are here scanty and precarious It appears that when nature has poured her bounty over Senegambia and Sudan, which are south of the Sahel, and has little more left to bestow, she sends a few smart showers of rain to the plains parched by the long presence of the perpendicular rays of the sun These happen between August and October, when the sun is leaving the northern hemisphere It is at this period of the year, and in the months which follow, that the inhabitants venture to pass from one inhabited spot to

another The wells are then full, if the rains have not fallen short of the usual quantity Though their number is small, and they occur only at great distances from each other, commonly ten or twelve days' journeys, they afford the means of filling the water-skins with which such travellers are provided. If the rains have been scanty or the weather unusually sultry, the wells are found dried up, and the travellers perish A few months after the rains, the hot wind which sweeps over these plains has dried up most of the wells and every kind of moisture This wind follows the diurnal course of the sun, blowing almost without interruption from the east, in the daytime, frequently with the violence of a gale, which, however, is generally followed by a dead calm after sunset The strong wind moderates the heat of the burning sun, and hence the nights are usually more insupportable than the noonday heat The violent gales frequently raise the loose sand in such quantities that a layer of nearly equal portions of sand and air, and rising about twenty feet above the surface of the ground, divides the purer atmosphere from the solid earth This sand when agitated by whirlwinds sometimes buries cafilas, and frequently puts them into the greatest confusion "One of the largest of these pillars of sand," says a modern traveller (Caillié), "crossed our camp, overset all the seats, and whirling us about like straws, threw one of us on the other in the utmost confusion We knew not where we were, and could not distinguish anything at the distance of a foot The sand wrapped us in darkness like a fog, and the sky and the earth seemed confounded and blended in one Whilst this frightful tempest lasted we remained stretched on the ground motionless, dying of thirst, burned by the heat of the sand, and buffeted by the wind. We suffered nothing, however, from the sun, whose disk, almost concealed by the clouds of sand, appeared dim and deprived of its rays." What a degree of heat travellers experience in this desert may be imagined, it cannot be described.

There are but a few species of wild animals in these wildernesses; lions and panthers are met with occa-

sionally; they prey on the gazelles and antelopes, which are found in the tracts overgrown with bushes. the first of these animals is rather frequent Ostriches are very numerous, and they are hunted by the natives in the months preceding the rains for their feathers No other birds are seen, except vultures and ravens Along the boundaries only are trees found, chiefly acacias and mimosas Towards the boundary of Senegambia are extensive woods of the first-mentioned trees, from which by far the greatest part of the gum is obtained which in Europe is consumed under the name of gum-arabic. In the worst parts of the desert a thorny plant occurs occasionally, which is about eighteen inches high, and remains green all the year round It is eagerly eaten by the camels, and is nearly the only plant which supplies them with food while thus traversing the desert. Without this animal it would be utterly impossible to cross the Sahel in the direction from south to north, therefore the Arabs call it "the ship of the desert"

It is hardly possible to comprehend what motives can have induced men to traverse a wilderness, in which they are exposed to the most exhausting fatigues and to every kind of privation, to hunger, thirst, want of rest, to the danger of being buried under burning sand, where an imminent death must be expected, and that of the worst kind, if it should happen that the water in the next well they are to arrive at be dried up. The desire of gain alone cannot account for it. It is probable that the first attempts were only partial, and were occasioned by one of the most remarkable productions of the desert —its extensive beds of salt They occur at several places, and we are acquainted with the position of three of them The inhabitants of the desert themselves make scarcely any use of it in their domestic economy. The countries, however, which border on the south of the desert have no salt, and consume large quantities of it. It, therefore, fetches a high price This probably first induced men to go half way into the wilderness to bring it to the market After they had succeeded, and learned to brave the hardships of these travels, they ventured to

advance farther northward, until they reached the cultivated country along the southern base of Mount Atlas. Then a regular commerce was established between the countries south and north of the desert, which is carried on by caravans or cafilas, as they are called in Africa, consisting of from two hundred to five hundred persons, and double or triple that number of camels The merchants bring from Sudan gold, ivory, and slaves, to which they add the ostrich feather of the desert, and they take in return European manufactures, tobacco, dates, and some other articles The starting points of the cafilas are Timbuctoo on the south, and Fez, in Marocco, on the north This route lies through the worst part of the wilderness, which is incapable of affording subsistence to a single family It appears that this route has been purposely chosen, the merchants being less afraid of the danger which they have to encounter in the desert, than of those to which they would be exposed by traversing a tract inhabited by numerous independent tribes, each of which is eager to enrich itself by plundering the cafilas, or by subjecting them to a heavy tax for the free passage through their territories There is another route across the desert, which lies farther east, and leads from the town of Kano in Sudan, to that of Gadamis in Tripoli, but we are not acquainted with it, as it has never been travelled by any European

The habitable portions of the Sahel are possessed by two nations of different origin To the west of the great route between Timbuctoo and Fez live the Moors, and to the east of it the Tuaricks The Moors of the Sahel are different from the Moors who inhabit the towns of Marocco They are Arabs, and resemble in almost every particular the Arabs who are settled in that empire, whose language they also universally use. In person they are generally tall and robust, with fine features and intelligent countenances Their hair is black and straight, their eyes large, black, and piercing, but lie deep in their sockets; their noses are gently arched, their faces long, their cheeks hollow, their beards full and bushy, and they have invariably good teeth They are more or

less swarthy, according to their proximity to the negro countries, until in some tribes they are found entirely black, but without the woolly hair, wide nostril, and thick lip, which particularly belong to the negroes

As no portion of the territories of these Moors is fit for cultivation, they have less means of subsistence than the Tibboos, and certainly have not attained an equal degree of civilization, at least as far as regards the manner in which they are lodged. As they live entirely on the produce of their herds, and the fertility of their lands is not sufficient to afford food to their animals for a length of time together, they are frequently compelled to move Hence they do not live in fixed abodes, but in tents which they remove from one place to another These tents are of a stuff woven from goats' hair and the fibrous roots of a plant Such a manner of life would necessarily have contracted the sphere of their ideas and conceptions, if they had not preserved some of the arts of civilized life which they inherited from their ancestors, for they are not aboriginals of Africa, but have immigrated into this desert, when their countrymen extended their conquests from Arabia to Spain It appears that at that period they exterminated the original inhabitants entirely, and then kept possession of their country The arts in which they have preserved a considerable skill, are those of tanning and preparing leather, of manufacturing, with only a hammer and a little anvil, bracelets, ear-rings, and necklaces of gold, and of making knives, daggers, and other arms they are also expert in weaving Their dress is the Arabic costume, which would appear decent even to Europeans if the arms were not left uncovered This is done with the view of being better able to use their weapons, which, besides fire-arms, consist of a spear and a dagger Their residences form circular encampments, consisting of from twenty to a hundred tents, where they are governed by a sheeck or governor of their own body Each encampment constitutes, as it were, a particular tribe, and the tribes bordering on each other are frequently at enmity, which, however, rarely leads to bloodshed, as they are

forbidden by their creed, that of Mahomet, from reducing one another to slavery. But where they live at a distance of only a few hundred miles from agricultural districts inhabited by negroes, they frequently make incursions for the sole purpose of capturing young persons to sell them as slaves. As they fall on their victims unexpectedly, and are besides superior to the negroes in boldness, activity, and skill in arms, these predatory expeditions are commonly successful. They are a daring set of people, and not restrained by any scruple in plundering, ill-treating, and even killing persons who are not of their own faith; but to such as are, they are hospitable and benevolent.

The boldest of these children of the desert are the Tuaricks, who occupy the middle of the wilderness, where it is widest. The form of their bodies and their language prove that they belong to the aboriginal inhabitants of Northern Africa who are known by the name of Berbers. They are a very fine race of men, tall, straight, and handsome, with an air of independence which is very imposing. The colour of their skin is almost white, the dark brown of their complexion being occasioned only by the heat of the climate; for those parts of their bodies which are constantly covered are as white as those of many Europeans. Their nose is aquiline, the eyes large, the mouth finely formed, the face long, and the forehead rather elevated.

In the north-eastern corner of their country some tracts occur where a small quantity of corn is grown, and where some plantations of dates are found, which yield a fruit of inferior quality. But the remainder of this extensive region can only be used at most as pasture-ground. The tracts yielding pasture are it appears numerous, but of small extent. This obliges the Tuaricks frequently to traverse large spaces of the sandy desert, and in these travels they acquire that hardiness of character, that firmness of resolution, that quickness of execution, that versatility of mind, and that boldness of enterprise by which they render themselves formidable to all their neighbours. They are always in a state of enmity with

the inhabitants of Sudan, from Lake Tchad to the town of Timbuctoo, making frequent predatory incursions into their country, and carrying off incalculable numbers of slaves. Their expeditions are executed with incredible speed. They use in them only the swift-footed camels, which they manage with great dexterity, fighting when mounted on them, and firing at marks while at full speed, which is a long trot. They are so completely masters of their weapons, and so courageous, that they are much dreaded even by the Arabs, which enables them to pass unmolested, and in very small bodies, countries full of armed people. Caillié states that two Tuaricks, mounted on one camel, arrived at a cafila, consisting of six hundred camels, and all the merchants vied with each other in offering them whatever they chose to eat, and plenty of water, though six days were to pass before they could arrive at a well. They exact a tribute also from all the caravans traversing their country, but in this they show moderation, as clothing, some powder, or any small article, franks the cafila, and this once paid the merchants are exempt from further demand. The Tuaricks wear a very cumbersome costume, as may be seen in Captain Lyon's Travels. This, however, must not be regarded as a sign of civilization, but as the effect of their frequent travels in the desert, where they are often overtaken by a sand-wind. To this necessity must also be attributed the practice of covering their faces as high as the eyes, so that their whole body, except their hands and a very small part of the face, is wrapped up in cotton or woollen cloth or in leather. As they are Mohammedans, they are obliged to perform three daily purifications, and as water is rare in their country they make use of sand in its stead.

Section XII.—The Selva, or Forest Desert of the Amazonas

The largest river of the globe, the Amazonas, in South America, drains the most extensive forest-plain we are acquainted with. It extends from the mouth of the river westward to the base of the immense rocky masses of the Andes, and in this direction measures at least 1500 miles. Its extent towards the south, and also partly towards the north, has not been exactly ascertained. But a supposition, resting on probable facts, assigns to it, near the mouth of the river, a width of 350 miles, which increases in proceeding westward, so that at the place where the Amazonas is joined by the Madeira the plain is at least 800 miles wide, and still wider where it reaches the Andes. Its surface probably comprehends an area of 1,200,000 square miles, equal to nearly half the extent of the Sahara, and to six times that of France.

The Amazonas is the only river on the globe which is always abundantly supplied with water by the tropical rains. In all the countries which lie south of the river, and are drained by its numerous affluents, rains are very frequent for six months of the year, and during two or three they pour down like torrents. They are less violent and abundant in the countries north of the river, but even these have a fair share of the tropical rains, which bring to the earth's surface between three and four times the quantity of rain which commonly falls on countries which like ours are situated in the temperate zone. It is easily to be comprehended that an almost incredible volume of water must be collected in the bed of the Amazonas. Where it issues from the mountains of the Andes, in which it originates, its width does not exceed a mile,

with a depth varying between seven and eight feet, but in proceeding farther east, and after having been joined by the Yupurá from the north, it widens to between three and four miles, at some places even to six, but a large portion of this wide bed is occupied by the numerous islands which the river has formed by depositing alluvial matter In these parts it is very deep perhaps sixty or eighty fathoms, but it has been impossible to sound it on account of the rapidity of its current, for it runs commonly at the rate of from three to four miles per hour This rapidity is not to be ascribed to the inclination of its bed, as its fall is very gradual, but to the immense volume of water which descends in it Towards its mouth the Amazonas widens to ten, fifteen, and at last to twenty miles, which is about its breadth where it falls into the Atlantic In despite of its rapid current this river affords a very easy and quick navigation both to vessels descending and ascending its course The ascent is partly effected by the means of the tide, which advances to a distance of five hundred miles from its mouth, to the Narrows of Obidos, and partly by the wind, which always blows against the course of the river, and by means of which ships, keeping near the banks of the river, and out of the strong current may ascend it almost with as much ease and in the same time as vessels can accomplish their voyages downward while descending and keeping in the current

Though the Amazonas always contains a large supply of water, its volume varies considerably according to the season The rivers which join it from the south, drain a much larger extent of country than those which fall into it from the north When therefore the sun has a southern declination the supply of water is twice or thrice as large as when the sun is in the northern hemisphere During the first half of the year its rising, and during the latter half the falling, takes place The difference of the lowest and highest level of the river is very considerable, amounting at some places to forty feet, but commonly to from twelve to twenty feet After it has received the vast supply poured into it by the

southern rivers, the water overflows its banks, and an immense tract of country is inundated, and the earthy particles which were held in suspension as long as they were in the bed of the river are then deposited on the inundated tracts Thus in the lapse of time an alluvial soil of great thickness has been deposited on these lands. This soil extends, with the exception of a few small tracts which are above inundation, to a distance of from six to twenty miles from the banks of the Amazonas As the soil of these low lands is extremely soft, water very easily removes it, and therefore all the smaller rivers and rivulets passing through them divide into several branches before they join the principal recipient of their waters At the base of the higher country also, which is above the highest level of the inundations, a depression is found, which almost everywhere skirts these higher grounds, and in which a considerable quantity of water gathers from all sides during the rains These depressions discharge the surplus of their waters by channels running across the alluvial ground In this manner, on both sides of the Amazonas, a kind of net-work is formed, of which low wooded islands represent the meshes, and the channels the threads This net-work is found not only on the banks of the great river itself, but also on those of its numerous large affluents All these large tracts are annually laid under water The higher grounds, which are not inundated, are mostly level, but at many places depressions of great extent exist, in which the water of the rivers, when it has attained its greatest height, penetrates, and by inundating the lower ground soon forms extensive lakes, deep enough to preserve the water all the year round These lakes discharge in the dry season a part of their waters, by narrow channels, into the next rivers, but during the rains the channels again carry the water from the river to the lakes, and raise their level, so that a great part of the adjacent tract is also inundated When the great number of large rivers draining the plain is taken into account, and the great extent of the low lands along their banks, and to

these the large tracts are added which lie within the higher grounds, but are subject to inundation from the numerous and large lakes, it may be considered perhaps as no exaggeration when it is stated that one-sixth of the great plain, or 200,000 square miles, are annually laid under water

The whole of this low region is covered with an exceedingly thick wood It is composed of large trees of various sizes and heights, and what is very remarkable, they differ greatly in species, no two trees standing together are of the same kind On a space of twenty square yards perhaps thirty or forty trees are found, but all of different species. The spaces between them are filled up with grass-trees and bushes of different kinds and sizes, standing close together, and the whole is united into one mass by numerous climbing plants and creepers, which as it were constitute the web of the tissue Thus a woody fabric is raised, as impenetrable to man as a wall of stone, and more difficult to be removed, near the ground only is found here and there a small and low opening, by which the jaguars and other wild beasts find access to the beds of the rivers. These woods can only be entered where they are traversed by water-courses deep enough to be navigated by canoes, but such attempts are usually very laborious. the branches of the trees overhang the channels from each bank, and as they are also entwined by climbing plants, the progress of the canoe can only be effected by cutting the branches. The larger rivers afford a more open and free access, but at many places similar obstacles occur in them

As these impenetrable woods, along the banks of both the larger and smaller rivers, surround the higher grounds which are not inundated, it is almost impossible to get access to them, nor does it appear that either natives or Europeans have ever settled on these tracts In the few elevations which approach nearer to the rivers, and which have been reached, it has almost always been found that they are also covered with wood, but of a character less

wild and dismal The variety and confusion of species are not so great, and the trees are commonly less incumbered with underwood and climbing plants.

At a great distance from the banks of the Amazonas there are savannahs, or woodless, grassy plains, which would afford good pasture-grounds, but have not yet been applied to that purpose, being situated too far from the settlements It is stated, that in those places where the great plain borders on the more elevated regions, these savannahs are more numerous and of greater extent

The climate of the plain of the Amazonas is distinguished by the quantity of rain, and by an excessive degree of heat The greatest fall of rain appears to be near the equator, along the banks of the great river Its annual amount has not been ascertained, but as, in the town of Maranhão, this quantity is not much less than two hundred inches, it is thought that it cannot be less on the banks of the Amazonas. No part of the year is exempt from rain It falls in greatest abundance between November and March, both months included, but is still frequent to the end of August In September and October rain is comparatively rare. These rains occur commonly every day, from two to four o'clock in the afternoon, and are accompanied by frightful thunderstorms The rain pours down in torrents, and Europeans who have not experienced it are unable to conceive its violence In receding from the equator, either south or north, the seasons become more regular, and between 10° and 20° of latitude, the year is divided between a dry and wet season The wet season occurs in the southern hemisphere when the sun has a southern declination, and very heavy rains fall in January and February, in the other months they are not so abundant nor so violent The quantity of rain which annually descends on this region is certainly less than that which drenches the country near the equator It is further observed, that the rains are less violent and abundant in those countries which approach the base of the Andes than in the eastern parts of the plain On the north of the river the countries drained by the affluents of the Amazonas do not reach be-

yond the limits where the equatorial rains prevail As the plain extends on both sides of the equator, the heat is excessive all the year round In the interior the thermometer in the shade rises frequently to 106°, when the sun is near the line, and this heat lasts from two to four o'clock, this is a degree of heat not much inferior to that experienced in the Sahara, but its effects on the human body are very different, for the atmosphere resting on the plain of the Amazonas is as distinguished by its humidity as that of the Sahara by its dryness The sandy desert is therefore healthy, whilst the forest engenders several kinds of fevers of the most noxious description, and enfeebles the frame so as to render it subject to many other diseases At the period when such a large part of the plain is under water, and also when the water begins to re-enter the beds of the rivers, the evaporation is, of course, excessive, and the atmosphere resembles a vapour bath But the heat, which causes this evaporation, brings the advantage, that at least a few months of the year are tolerably healthy, namely, the three or four months which precede the rising of the Amazonas in February If the heat was not so excessive it would not dry up the numerous temporary lakes which are left in the plain by the inundations, nor the large tracts of low marshy ground which during the rains had been converted into swamps

Moisture and heat are the most effective agents in promoting vegetation, and where both are combined in acting upon a fertile soil, the growth of every kind of trees and plants exhibits an uncommon luxuriance No soil is more fruitful than that portion of the plain which is subject to annual inundations hence we find it clad with impenetrable woods, which cannot be cleared but by uninterrupted efforts of severe labour When that has been done, it requires continual attention to keep it clear, otherwise it is again soon overgrown by weeds and bushes Travellers have visited spots where Europeans had formed settlements, which for some reason had been abandoned In ten years they are found overgrown with tall bushes, and in twenty with lofty trees, so that all

traces of the industry of man had been completely obliterated, and nature in its wildest form had again taken possession Though the labour of clearing such lands is very great, the return is in proportion A space of an acre or two, planted with bananas or mandioca, yields a produce sufficient to afford subsistence to the largest family but there are only a few isolated and small tracts, which are besides favourably situated, that have been as yet brought under cultivation The natives here and there cultivate some small spots, in the most slovenly way, more for the purpose of using their produce for the preparation of inebriating liquors than for sustenance, as they prefer animal food, which is everywhere exceedingly abundant, especially as they are not particular in their tastes Near the settlements of the whites the cultivated spots are more extensive, but still not on a large scale, and their number is small The woods, however, produce a great variety of fruits and roots which are edible, and besides yield most other objects required in their domestic economy They afford also articles for exportation, which are in great request, as vanilla, sarsaparilla, caoutchouc, Brazil-nuts, tamarinds, anotto, clove-cinnamon, besides different kinds of balsams and gums, as copal and copaiva, and several species of woods used as dyes, or for cabinet work There cannot be the least doubt that the number of these articles will be greatly increased when these forests shall have undergone the examination of scientific botanists, and their produce have been subjected to trial. The vegetable riches of these forests will probably be found more numerous and more abundant than those of any other part of the globe

Not less rich is the animal creation Those which at present occupy the first place in the domestic economy of the natives are fish, with which all the rivers, small and large, swarm It is their great abundance, and the facility with which they are caught, which renders the natives averse to every other kind of labour, and secures them an almost certain subsistence without the least care or attention. They have discovered different kinds of plants by which they are able to stupify or kill the fish

in the water, and thus procure, by working a few hours and without any effort, a supply for many families and for many days The number of the species of fish is great, and some of them attain a large size Next to fish the river-turtles are of the greatest importance. Though not of a size to be compared with the sea-turtles, they are numerous, and from the eggs they deposit on the sandy islands of the Amazonas, a fat is extracted, which, under the name of manteca, is largely consumed in all the provinces of Brazil, and constitutes a chief article of commerce In some of the larger establishments of the whites, these animals are kept in enclosures made within the bed of the river where it is not deep, and they supply the place of butcher-meat for the table The largest inhabitant of the river is the manatee or sea-cow, which is not frequently met with, being eagerly sought after by the natives, and the alligator. But though the river teems with animals, the land is in some respects deficient, at least according to our conceptions There are no ruminants, the closeness of the woods precluding their existence * The jaguar, which is here of larger size than in any other part of America, and approaches in ferocity and strength to the tiger of Asia, lives on fish, turtles, and monkeys It is said that it frequently attacks and vanquishes the alligator The real population of the woods are the monkeys, they are found in incredible numbers and of many species, some of which are of large size They are hunted by the natives, who dry and eat their flesh Birds are exceedingly numerous, and some of them have been partially reduced to a domestic state Serpents, even venomous ones, are frequent, but not half so dreaded as the mosquitos, and several kinds of gnats, as *piums*, *maruims*, *carapanás*, &c., which torment the inhabitants so as to render their lives miserable.

It is evident that these evils, as well as some others

* It is probable that in those parts where savannahs occur some of the smaller species may be found, but we are not acquainted with this fact.

which beset human life in the plain of the Amazonas, would be removed if the forests were cleared and the swampy grounds drained, and thus the whole converted into an abode for man. But here the question obtrudes itself, why has it not yet been done? Why has this large country remained since the creation in this state of wildness and desolation, in which it is at present? When we find that there is no country on the face of the globe which can be compared with this plain in the productiveness of its soil, in the creative powers of its climate, which everywhere imparts to its plants and trees the most uncommon luxuriancy of growth, and which fills every corner with animal life of the most various kind—when we hence conclude that such a country must afford the most abundant, almost inexhaustible, means of subsistence to man, and not only provide for his necessities, but also supply luxuries of every description, so as to satisfy the most fastidious appetites and desires—when all this is taken into account, we should expect that such a country, at a very remote period, would have risen from its state of wildness, would have become the centre of a widely-spreading civilization, and the seat of powerful empires, which would have secured peace and protection to many hundred millions of inhabitants by a regular and well-settled government and humane and wise laws In what condition is its present population? It consists of a number of savage tribes, all of them composed of a comparatively small number of families, some only of three or four. These tribes speak different languages, and have no intercourse with each other, so that they are not acquainted with the language of their neighbours When the individuals of one tribe visit another, it is only for the purpose of making prisoners, whom they fatten to be eaten at a national festival They are without government, without any social ties, without religion When their character and manners, their occupations, food, abodes, and dress are considered, we are tempted to think that they are half-beasts, and little above the brute creation

It may appear harsh to pronounce such a sentence on

any, even the smallest fragment, of the human race; but let us consider the condition of one of these tribes, living in the interior of the woods, and, as some travellers would say, not tainted with the vices of civilization. The Miranhas live on the banks of the Yupurá, above the cataracts of Cupati. They are, indeed, not entirely unacquainted with the cultivation of the ground, but it is limited to very small spots, on which they grow mandioca, banana, and anotto; none of the men taking part in working the field, the labour devolving on the women, who are considered as slaves. The men live in idleness at home, eating, drinking, dancing, and sleeping. Sometimes they go out hunting monkeys, or fishing in the river. When one of them intends to make an attack on a neighbouring tribe, he soon finds a few associates. The men wear a stripe of the inner bark of a tree wound round their loins, and another passes between the legs; the women go quite naked, but they paint their whole body, and this, it seems, they consider as a dress. Both sexes perforate the sides of their noses, and place in these holes short thick sticks, by which the parts are so thrust out that they can put them over their ears. This is considered a beauty. In their food they are far from being delicate, but except some cakes made of cassava-flour, and a few bananas, they do not taste vegetable food. When they have monkey-meat or fish, they live on them; but as that sometimes is not at hand, on account of their want of providence and inclination to idleness, they eat alligators, serpents, toads, frogs, ants, grubs, and caterpillars. Their huts consist of a few pieces of wood stuck into the ground, covered on the sides and at the top with palm-leaves; they are rather spacious, and are commonly inhabited by several families. They have a few cooking utensils made in the rudest manner. The rest of the furniture is limited to hammocks, made by the women from the internal bark of the tirri-tree, and which are so neatly constructed that they are greatly prized by the European settlers, and are in demand even in Surinam and Demerara, to which places many thousands are annually shipped from Para. Ex-

cept in the manufacture of these hammocks, and in the little care with which the women cultivate a field or two near their huts, we find that this nation is at the lowest scale of civilization, as low as human beings can be.

This becomes more evident when we consider the state of their minds and their domestic relations. They have no idea of God, but imagine that their fate is dependent on the caprice of a bad demon, whose favour cannot be acquired by any action, good or bad. They live only for the present moment, and do not trouble themselves with futurity, and have not the least conception of the immortality of the soul, of future rewards or punishments. Life is considered as being of little value, and death as quite indifferent. Everything is terminated by death, except hatred and the desire of revenge. No affection exists between the sexes, the man associates himself with a woman, and dismisses her at his pleasure. The connexion between them resembles that of beasts of prey; the man cares not for his family so long as he himself is satisfied, and considers his children as a burden, which he endeavours to shun. The children grow up, spoiled by the mother who treats them as playthings, and neglected by the father, without affection for the one, without respect for the other. As soon as a boy thinks himself able to get his subsistence, he emancipates himself from the authority of his parents. Persons who fall ill are neglected and abandoned, because their nursing would subject their attendants to inconvenience which they will not undergo. Every one is his own master, and does as he pleases, and as long as he does not offend anybody he has nothing to fear. These people have no chiefs, and do not obey any orders, except in war, when they subject themselves to the command of him who has projected the enterprise, or has acquired a name by his valour. Since they have begun to have intercourse with the Europeans settled on the banks of the Amazonas, those who have the means of promoting this intercourse have assumed a kind of authority. The only foreign article which is in demand is spirits, for which they give in return the hammocks

made by their women, and the prisoners who have fallen into their hands in their military expeditions.

In these expeditions they show that there is not a germ of human feeling in their mind, and display the ferocity of beasts They do not act as open enemies, nor have they the ambition of vanquishing their adversary, or of obtaining a victory They imitate the habits of the jaguar When after a march of many days they approach a settlement belonging to a tribe at enmity with them, they conceal themselves in the woods and bushes, and, when satisfied that nobody is aware of their being near, fall suddenly on the unsuspecting inhabitants, kill all who make the least resistance, take the others prisoners, and oblige them to carry to their own homes the provisions, arms, and utensils which they find in the place When they have returned to their own settlement they abandon themselves to every excess in eating and drinking, and accompany their feast with frantic dances and undescribable noise. At present they have an opportunity of disposing of their prisoners as slaves to the Europeans settled on the banks of the Amazonas, but it is probable that formerly they ate them all they still eat some of them When Martius, a German naturalist who visited this part of the plain of the Amazonas, and to whom we owe this account of the Miranhas, questioned their chief respecting their eating human flesh, he did not deny the fact, but defended the practice by saying, "You whites do not eat alligators and monkeys, though their flesh is well tasted, if you had not an abundance of turtles and hogs you certainly would not be so particular, for hunger is urgent Everything is habit. When I have killed an enemy I think it much better to eat him directly than to abandon his flesh to putrefaction Large animals are rare, because they do not lay eggs like the turtles There is no misfortune in being eaten Death alone is a hard thing When I am killed it is no matter to me if my enemies eat me or not I do not know any kind of animal that has a better taste than our enemies, but the flesh of the whites is tough and sour. I should, however, show very little

prudence in eating my prisoners now I have an opportunity of bartering them for spirits Spirits have a much better taste than blood. But when I take for prisoner one of the Umáua (a tribe with which the Miranhas have a perpetual feud) I kill him directly and eat him, because I am certain that he will starve to death rather than be sold as a slave to the whites" The other native tribes, who are no longer men-eaters, are in great dread of those tribes who have preserved this practice, and narrate with horror that a chief living on the banks of the Rio Negro more than a hundred years ago ate his own wives

Those tribes which have for some length of time had an intercourse with whites have abandoned the practice of eating human flesh, but it is said that they have contracted a timidity, and evince more cunning, deceit, and lowness of mind, than their neighbours They have not improved either in other respects. All of them still exhibit a monotonous poverty of intellect and mental torpor, and neither internal emotions nor the impression of external objects are able to rouse their minds from this lethargy Neither their food nor their dress and habitations have been changed, though they have for two centuries had those of the white settlers under their eyes. They adhere to their ancient usages and practices with an obstinacy which certainly deserves the name of mental torpor If even they were more accessible to innovation, their ideas of property would much oppose their improvement. Each tribe has its peculiar hunting-grounds, which are marked by well known boundaries, and wherever settled for a time, each tribe or family has its own plantation, which is cultivated by the women for the use of the community Huts and utensils are considered as private property, though with regard to them certain ideas of common possession prevail. The same hut is often occupied by more than one family, and many utensils are the joint property of all the occupants. Scarcely anything is considered as strictly the property of an individual, except his arms, dress, pipe, and hammock. It is evident that under such circumstances no one could

think of accumulating property or of anything beyond the supply of the present wants Thus the strongest of all stimuli to industry and economy, next to hunger, is wanting among them, and consequently all improvement resulting from that source becomes impossible

Experience shows that the tribes of the plain of the Amazonas have learnt nothing by mixing with the whites, neither can they improve by an intercourse with their neighbours, for besides that the usages and practices prevailing among these tribes greatly resemble one another, intercourse is precluded by their never-ceasing enmities, and still more by the different languages spoken "Out of twenty Indians," says Martius, "whom we employed as rowers in the boat in which we navigated the streams of the interior, there were often not more than three or four who understood any common language, and we had before our eyes the melancholy spectacle of persons occupied in the same labour, but entirely isolated with respect to everything which contributes to the supply of the first wants of life In gloomy silence did these Indians ply the oar together, but no common voice nor interest cheered them as they sat beside each other in a journey of several hundred miles, which their various fortunes had called them to perform together"

That nations which are in a state of such abjectness, and do not evince the least inclination to improve their condition, cannot under any circumstances be expected to render the plain of the Amazonas fit for the abode of civilized man is self-evident The arts and comforts of civilized life must be planted by foreign hands Three centuries have now elapsed since the Amazonas was first navigated by an European In the last two centuries the Portuguese have frequently ascended and descended the river, and during that period settlements have been made at many places by that nation But still we find that the number of these settlements is few, and that, with the exception of three or four, which are most favourably situated for commerce, their population is very scanty, commonly consisting of a few families in which

the number of negroes and other slaves is much greater than that of the whites. Many settlements, formed at places which promised great advantages, have been abandoned, and the wilderness has again extended over tracts which were once cultivated by careful hands. Every part of the Brazilian empire has greatly increased in population, industry, and the arts of civilized life, during the last forty years, but the plain of the Amazonas has remained stationary. Officers who are sent there by the government consider it as a place of exile, and count the weeks and months by the lapse of which they will acquire a right of being recalled and sent to other parts. Persons who by the laws have been condemned to transportation are sent to one of the settlements on the Amazonas. The prospect of accumulating in a short time a large fortune, has also induced many industrious persons to settle, but they look anxiously forward to the day on which after having attained their object, they will be enabled to leave the country. They do not think of acquiring extensive landed property, or of settling their families permanently. It is not the want of society or of comforts which drives them away, it is the melancholy and irresistible feeling, which imperceptibly creeps into the mind, that they are placed in a desert which cannot be rendered a comfortable home by human industry.

The industry of man has in all other countries succeeded in subjecting the productive power of nature to his sway, and to direct its operation to his ends. In the Sahara it has taken possession of all the resources of the country till it has arrived at the very limits which nature herself has fixed. No farther improvement can there take place. In some countries situated within the polar circle, a course of improvement has been adopted and is pursued with success. Its progress is slow, but certain. The ungrateful soil of the Falkland Islands has fallen under the fertilizing hand of man, and will doubtless be converted into fruitful fields in the progress of time. But there is little hope that such will ever be the case with the plain of the Amazonas. The produc-

tive powers of this country, it appears, are too great and too active to be subdued If its soil was but half as fertile, its air half as moist, and its vegetation half as vigorous as it is, man would easily master nature and compel it to administer to his wants, or to supply him with riches But he finds here all the efforts of his industry are in vain, he is overwhelmed by the bounties of nature His mind sinks into despair when he contemplates the immense work before him, whilst his body feels the exhaustion produced by that climate which imparts to the soil its never-ceasing power of reproduction He finds himself reluctantly compelled to abandon his plans, and to leave to nature that portion of the globe which she seems to have reserved for her exclusive property, and for her unfettered operations The plain of the Amazonas, is, perhaps, destined to remain for ever a wilderness

Section XIII.—The Pampas.

The forests of the plain of the Amazonas extend along the base of the Andes as far south as 12° S lat., where the mountains of Brazil advance so far westward as to leave between them and the Andes what may be called an immense valley, for it is at an average 200 miles across This valley runs in its northern part, and as far as 18° S lat, from north-west to south-east, but its southern part extends due north and south It terminates near 22° S lat, so that its whole length is not less than 700 miles In this valley the country changes its aspect by degrees Its surface is not covered with interminable forests, but presents in the northern districts an alternation of woods and swampy tracts, which are partly overgrown with bushes and partly clad with grass In proceeding southward the woods continue to be frequent, but less extensive, and the swampy grounds gradually give way to a drier country These swamps owe their origin to the tropical rains Where these terminate (about 20° S lat) they are succeeded by a region whose surface is dry all the year round, and which is covered in general by a coarse grass, and in some parts by numerous bushes.

The valley just noticed leads from the forest-desert of the Amazonas to the *Pampas*, treeless plains, which from 22° S lat extend to the most southern limits of the American continent, and terminate on the Straits of Magelhaens, near 52° S lat, so that they occupy from north to south a length of 2000 miles Its width is various Between 22° and 26° S lat it does not exceed 280 miles, but between 26° and 38° it is full 450 miles, between the river Pararà on the east and the Andes on

the west Farther south it contracts to 360 and to 240 miles, which is its average width between 42° and 52° S lat According to a rough estimate its area is about 750,000 square miles, or nearly four times the extent of France

This plain presents in its different parts a much greater diversity in surface climate, and productive powers than the forest-desert of the Amazonas, or the Sahara The most southern portion, or that which lies south of 40° S lat, is called the *Pampas of Patagonia*, being inhabited by several tribes which are comprehended under the generic name of Patagonians We have as yet obtained very little information respecting these pampas It appears that from the shores of the Atlantic the country rises gradually in proceeding westward until it joins the base of the Andes At some parts the slope has the form of an inclined plane, whose surface is somewhat hilly, at others the rise is effected by a considerable number of terraces, which grow higher and higher in approaching the mountain-range on the west In the southern part a great portion of the surface of the plain appears to be overlaid by a thick layer of lava, which doubtless is derived from the numerous volcanoes which existed and still exist in the Andes These parts are very sterile, but north of 46° S lat, a large part of the country is clad with grass which affords pasture-grounds for the numerous herds of the Patagonians. But even here there are few trees, and water is scarce, as rain seldom falls. The heats of summer are very great, but in winter, though the days are not cold, the frosts at night are severe, and at all times of the year, in the day-time, strong winds sweep over the plain

The Patagonians have been considered as the tallest race of men since they were first visited by Magelhaens Some navigators say that they have seen among them persons nine or ten feet high, and in the last century Captain Byron, who was nearly six feet high, tried to measure one, and found that when on tiptoe he could but just reach with his hand the top of the Patagonian's head There are not wanting other witnesses

to confirm this account Though the most modern navigators have not met with persons of such a size, Captain FitzRoy states, that he has nowhere met with an assemblage of men and women whose average height and apparent bulk approached to that of the Patagonians. Among two or three hundred of them scarcely half-a-dozen men are seen whose height is under five feet nine or ten inches, and the women are tall in proportion Their heads and features are large, but their hands and feet are neither so muscular nor so large-boned as their height and bulk would induce one to suppose, they are also rounder and smoother than those of white men Their colour is a rich reddish-brown, between that of rusty iron and clean copper, rather darker than copper, but not so dark as good old mahogany Nothing is worn upon their head except their rough, lank, and coarse black hair, which is tied above the temples with a fillet of plaited or twisted sinews Large mantles made of skins sewed together, loosely gathered about them, hanging from the shoulders to the ankles, add so much to the bulkiness of their appearance, that one ought not to wonder at their having been called gigantic They paint their bodies with black, red, and white paint, with which they make grotesque ornaments, such as circles round their eyes, or great daubs across their faces On their feet are boots made out of the skins of horses' legs Wooden spurs, if they cannot get iron, sets of balls united by thongs called *bolas*, and a long tapering lance of bamboo, pointed with iron, complete their equipment The women are dressed and booted like the men, with the addition of a half-petticoat made of skins, if they cannot procure foreign coarse cloth They clean their hair, and divide it into two tails, which are plaited, and hang down one on each side

Their huts are in shape not unlike gipsy-tents Poles are stuck in the ground, to which others are fastened, and skins of animals sewed together form the covering, so that an irregular, tilt-shaped hut is thus made Three sides and the top are covered, but the front, turned towards the east, is open. These huts are about seven feet

high and ten or twelve feet square, they are lower at the back or western side by several feet. They have no other furniture but their arms and hides to sleep on. Among their arms the balls or bolas are the most formidable. They consist of two or three round stones, lumps of earth hardened, iron or copper ore, or lead. These balls are connected with one another by thongs equal to one another in length, with their inner ends united. Taking one ball in the right hand, the other two are whirled round several times, and the whole then thrown at the object to be entangled. They do not strike the objects with these balls, but endeavour to throw them so that the thong shall hit a prominent part, and then of course the balls swing round in different directions, and the thongs become so twisted, that struggling makes the captive more secure. A powerful missile is formed of a single ball, similar in substance and size to the others, but attached to a slighter rope about a yard long. Whirling this ball, about a pound in weight, with the utmost swiftness round their heads, they dash it at their adversary with almost the force of a shot. At close quarters it is used with a shorter scope of cord as a very efficient head-breaker.

The principal subsistence of the Patagonians is the flesh of mares, ostriches, cavies, and guanacoes, but though they are not particular, and eat almost anything that they catch, the flesh of young mares is preferred to any other. They broil or roast their meat, and eat it with a lump of fat and salt. They eat also two kinds of roots growing wild in their country, after having roasted or broiled them. Dogs are kept for the chace, but not eaten, nor are horses, unless disabled by accident. In some parts cattle are rather numerous, but their flesh is not thought equal to that of mares.

They do not cultivate any kind of plant or vegetable, and are remarkable for uniting more closely together than other nations the occupation of herdsmen and hunters. To this circumstance, probably, it is to be ascribed that none of their tribes claim an exclusive right of property to any part of the country, and that they traverse the

whole plains freely and without any prejudice to others between 40° and 52° S lat They are much given to this wandering life, and travel with great expedition. The same tribe has been found in September on the shores of the Straits of Magelhaens and in the following February on the banks of the Rio Negro, distant nearly a thousand miles from one another It is, however, probable that those tribes which have cattle do not remove far from the places affording pasture-ground for these animals, which are not frequent, and only met with in some parts of the country Travelling appears their principal occupation, and hunting is occasionally resorted to when there is a scarcity of food The whole tribe then collect together, surround a considerable tract of country, and kill with the bolas all the animals thus enclosed They have dogs to assist them in their hunting The produce of the chace is divided among the different families, in proportion to their numbers

The Patagonians have more exclusive ideas of property than the native tribes in the woods of the Amazonas. Among them are rich and poor people. Their wealth consists chiefly in horses and dogs, the richer individuals having forty or fifty horses and a large number of dogs, the poorer only one or two horses and but one dog But respecting other objects their ideas of property are less fixed When, for instance, one family has eaten its share of the chace sooner than others, any one that is hungry goes to a party which has meat left, and cuts off what is wanted without a question Their ideas and usages also show that they have attained a higher degree of civilization than the native tribes of Brazil They have a multiplicity of deities, some good, some evil, and believe that the first reside in vast caverns under the earth When these good deities made the world, they first created the Patagonians in the subterranean caverns, gave them the lance, the bow and arrows, and the balls, and then turned them out to shift for themselves. They imagine that the deities of the Spaniards created them in the same manner, but that, instead of lances, bows, &c , they gave them guns and swords. They say that when

the beasts, birds, and lesser animals were created, those of a more nimble kind came immediately out of the caverns, but that the bulls and cows being the last, the Patagonians were so frightened at the sight of their horns, that they stopped the entrances of the caves with great stones Therefore they had no cattle in their country until the Spaniards, who, more wisely, had let them out of their caves, brought them over The Patagonians have also an idea of immortality, for they think that their souls go to the caves to live there with the deity who presides over their particular race They have also a kind of religious worship, but this is entirely directed to the powers of evil

Marriages are more frequently made by sale than by consent Inclination may sometimes determine the choice, but payment must in every case be made in proportion to the supposed value of the damsel and the property of the purchaser Each man has commonly only one wife, but a few, who have forty or fifty horses and other riches in proportion, have four or five wives The women are very faithful and laborious Their lives are one continued scene of labour, for besides nursing and bringing up the children, they are obliged to do most of the drudgery. Except hunting, providing food, and fighting, all work is done by women Man and wife seldom forsake each other, even in extreme old age The husband rarely beats his wife, but their passions, unrestrained by civilization, occasionally run extremely high, and at such times they spare nothing in their fury They take great care of sick persons, and show much attention to old age

Their caciques or chiefs are hereditary, but their authority is very limited In cases of importance they are assisted by a council of the principal individuals and wizards They have not the power of raising taxes or of taking anything from their vassals, but are, on the contrary, obliged to treat them with great humanity and mildness, and often to relieve their wants, or they will seek the protection of some other chief For this reason many who are born caciques refuse to have any vassals,

as they cost them dear, and yield but little profit No individual or society, however, can live without the protection of a cacique, according to their law of nations, and were any to attempt to do so, they would undoubtedly be killed, or carried away as slaves, as soon as discovered The prerogative of the cacique consists chiefly of his power as a magistrate and judge, and he may punish as he pleases, even with death, without being answerable for it He it is, also, who gives directions to encamp, march, travel from one place to another, to hunt or make war

The Patagonians, like the Jakutes in Siberia, do not appear to be very sensible to heat or cold, if we may judge from their habits of life and from their clothing. The only difference in their dress during the winter is that they more constantly wear horse-hide boots In summer their feet and legs are generally naked They are not of a quarrelsome disposition The wars between the single tribes are not frequent, and never last long, nor are they carried on with cruelty They are friendly to the crews of the vessels which visit their shores Europeans commonly regard them for some time with distrust This is owing chiefly to the singularly wild look which characterises all uncivilized tribes, and which is particularly conspicuous in the Patagonians, but of all savage nations, perhaps, these tribes are least inclined to attack or deceive strangers

North of the Pampas of Patagonia are the *Pampas of Buenos Ayres* They extend from 40° to 34° 30′ S lat, and reach from the shores of the Atlantic to the foot of the Andes Though in general a plain, their surface exhibits in several parts a considerable degree of variety That portion of it which lies east of 61° W long. is far from being level, but all the inequalities of its surface are too inconsiderable to be called hills, except in the southern districts, where several ridges of high land with flat tops occur, which run from south-east to north-west, and lie in two lines, with, however, many interruptions in their continuity A great portion of the country lying between the two lines of hilly ridges, as also a very large

tract north of the northern line, are covered with swamps thickly set with canes and reeds, and interspersed with numerous but shallow small lakes and ponds This country resembles the better part of the Cambridgeshire fens, and would, if drained, afford excellent pasture-grounds These fens owe their existence to the flatness of the surface, and to the numerous streams whose waters cannot make their way to the sea, or the rivers in the vicinity, for want of a sufficient descent These swamps do not extend to the banks of the river Salado, which are firm, and are even at present used as pasture-grounds. North of that river the plain is only broken by ascents and descents so slight as to be almost imperceptible, and its whole surface is covered with luxuriant coarse grass, growing in tufts, and partially mixed with wild oats and trefoil. Extensive tracts are entirely overgrown with thistles from six to eight feet high, which are used for fuel, as the country is entirely devoid of trees and shrubs Near the dwellings of the inhabitants are small plantations of peach-trees, also used as fire-wood The depressions of the surface are numerous but shallow, and in them the water collects during the rains and forms pools This evaporating after a continuance of dry weather, the depressions become covered with rich grass, which supplies pasture during the dry weather, when the grass of the higher grounds has been parched up by the heat Thus their country is able to maintain immense herds of cattle and horses When pastured the coarse grass and thistles gradually disappear, and are replaced by a fine and thick turf The soil, however, is not less fit for agricultural purposes, and in recent years abundant crops have been obtained from it, especially of wheat It is certainly a drawback that the water of all the rivers is salt, especially in summer, when their volumes are much diminished This appears rather remarkable, as it is stated that the country which they drain is not impregnated with saline matter, for fresh water is found at no great depth under the surface almost everywhere, and thus wells are easily dug As the population of this region is composed of agriculturists of Spanish origin,

nothing particular is found in their character, manners, or practices which deserves to be noticed

The western portion of the Pampas of Buenos Ayres is divided into a pastoral and an agricultural district, separated from each other by a line not much differing from the meridian of 66° W long The pastoral district is east and the agricultural west of that line In the country which surrounds the sources of the Rio Salado, the soil of the plain begins to be impregnated with saline matter, and continues more or less so to the base of the Andes Its surface may be called a dead level, as the depression and elevation are imperceptible to the eye, but that such depressions and elevations exist is evident by the state of the country after the rains, for the lower grounds are then found covered with extensive saline swamps overgrown with reeds, and where the swamps are very shallow they are encrusted with a saline efflorescence The more elevated tracts intervening between these swamps are clad with a coarse grass, which attains a height of six feet, and resembles rye or wild oats. The grass occurs in clumps, and is salt to the taste In every part of this larger tract are shallow lakes containing salt water, and some of them are from ten to twenty miles long, and nearly as wide One shallow depression occurs of such an extent that it is fifty miles long, and twenty wide During the rains, when several small rivers flow into it, this is converted into a temporary lake, but towards the end of the dry season the evaporation has carried off nearly the whole body of water, which is then only found in numerous small ponds interspersed within the depression. The soil is stated to be good, consisting of a dark friable mould without a pebble The most remarkable feature of this extensive country is the total absence of permanent water-courses. After a continuance of heavy rains, or when the rivers rising in the Sierra de Cordova are filled by the melting of the snow, they reach the plain lying south of them, but their water is spread over the depressions above noticed These rivers, however, cease to flow in the dry season Next to this the absence of trees is the most striking peculiarity A few

copses of small trees, mostly peach planted for fuel, and some small groves near the habitations of the inhabitants, are all that are found. It is difficult to discover a sufficient reason for this deficiency, as the country is covered with a great depth of alluvial soil, and as trees are abundant in most of the adjoining districts Several causes probably concur in preventing their growth the furious storms which sweep along the level surface, the want of water during a part of the year, which is sometimes so prolonged as to become a severe drought, and the numerous herds of wild cattle which range over the plains, and eat up every leaf which retains any moisture during the dry heat of summer. The salt with which the soil is generally impregnated cannot account for their universal absence, as trees are not found in places where such is not the case Besides, it is an ascertained fact that trees grow in the saline districts where they are planted and partially sheltered.

This portion of the western Pampas of Buenos Ayres, as well as the whole of the eastern, appears to be one immense bed of alluvium, and scientific men have endeavoured to explain in what way this alluvium has been formed Most of them incline to the opinion that it has been tranquilly deposited by waters which have originated in the Andes, and have flown with a gentle course to the Pacific That may have been the case What, however, renders this thick stratum of alluvium most remarkable is the circumstance that the fossil remains of gigantic animals, of long lost species, are here found imbedded, such as those monsters which have been named by our naturalists megatherium, mastodon, glyptodon, &c These fossils are also much more common than was supposed, and when carefully sought after are found at numerous places during the dry season, or after long droughts either in the banks of the rivers or in the beds of the numerous lakes which are then dried up None of these now extinct species appear to have been animals of prey, but all herbivorous. It is also remarkable that no skeletons of animals now living in these regions have yet been discovered in this alluvium.

The climate of these plains is also distinguished by several peculiarities, at least when compared with European countries. The cold of the winter is not much experienced in the town of Buenos Ayres, where the thermometer does not usually descend below 36°, and very rarely to 28° or 29°; but in the Pampas, and at some distance from the sea and the river Parana, it descends every year below the freezing point for several nights together, and occasionally several degrees. On the other hand, the number [illegible] days in the capital is but small in comparison [illegible] are rainy; but in the plains [illegible] very dry, rain not falling [illegible]. Sometimes several months [illegible] these droughts numbers of cattle [illegible] and at some places for want [illegible] entirely dried up. But the most [illegible] hurricane-like storms [illegible] They occur [illegible] of northern wind and [illegible]. Before the setting in of the storm, clouds gather in the [illegible] which soon assume a singularly hard and rolled [illegible] appearance, like great [illegible] continually altering their [illegible] by gusts of hot wind, blowing [illegible]. Then suddenly the storm [illegible] from the snow-capped [illegible] down with an undescribable [illegible] Pampas, and ere it reaches [illegible] becomes a hurricane. [illegible] accompanied by clouds of [illegible] so dense as to [illegible] as it were, to the [illegible] are unable to find [illegible] Buenos Ayres [illegible] drowned [illegible] These clouds are often [illegible] of rain which, mingling with the [illegible] forms literally a shower of mud. [illegible] is accompanied with the most [illegible] thunder and lightning.

doing great damage and frequently attended with loss of life The shipping in the La Plata river always suffers greatly from a pampero, and the loss of property is considerable The force of these storms must be immense, as it is able to remove heavy bodies to a great distance Captain FitzRoy mentions that a small boat, before the setting-in of the storm, had been hauled ashore just above water-mark, and fastened by a strong rope to a large stone, but after the storm it was found far from the beach, shattered to pieces, but still fast to the stone, which it had dragged along

When the Spaniards took possession of these plains they were pastured by large herds of guanacoes or llamas, but these animals have nearly disappeared, giving way to cattle and horses, which are now found there in great numbers Some writers say that there cannot be less than one million of cattle, and three millions of horses Some other wild animals, however, have kept their footing The most remarkable is the emu, a kind of ostrich, the chace of which affords quite as much amusement to the wild *Gaucho* as hunting the fox to the sportsman in England, and the horses are trained to pursue it in all its shiftings and mazes The Gauchos hunt them for their feathers, and use for that purpose the bolas The hunters whirl these balls round their heads while in pursuit, and throwing them at the bird when sufficiently near, they twist round its legs and bring it to the ground There are numbers of small deer in these plains, but as their flesh is not much esteemed by the natives they are not molested The biscacho, an animal between a rabbit and a badger, is peculiar to these plains, in which it burrows more or less in every direction, so as to render travelling dangerous, particularly by night, their holes being so large and deep that a horse is almost sure to fall if it steps into one of them. Their flesh is much relished by the people, and they are hunted with dogs, against which however they defend themselves for a considerable time The armadillo is also found, and is in great esteem among the natives for its flesh

After the Spaniards had got a firm footing on the

banks of the Rio de la Plata, the native tribes, resembling the Patagonians in their roving propensities and manners left the neighbouring countries, and the Spaniards dispersed over the plains As they found the pasture-grounds, as it were, boundless, they abandoned the idea of cultivating the ground, and formed numerous cattle-farms at great distances from each other. Although these settlements are frequently attacked by the savage tribes, they have continued this manner of life for nearly three hundred years This has impressed on their character, habits, and costume, such peculiar features that they are considered as a distinct nation, and distinguished by the name of *Gauchos* These people may be said to live on horseback, for they never move a hundred paces from their habitations without mounting a horse, one always standing saddled before the door A Gaucho is clad in the *poncho*, which is manufactured by the women It is about the size and shape of a small blanket, with a slit in the centre to admit the head. It therefore serves to keep out the wet and wind, and leaves the arms at perfect liberty The poncho was originally an Indian garment, and is generally made of wool, beautifully interwoven with colours It is sometimes worn slung across the shoulders, sometimes as a belt, but is always used for a blanket at night The jacket of the Gaucho resembles the jackets worn by the Spanish peasantry, and is made of coarse cloth or baize, or of velveteen, his breeches, made of the same materials, are open at the knees His leggings are composed of horse-hide, and his toes are left bare A straw hat, with a cotton handkerchief tied round his face, complete his dress. He is always armed with the bolas, which were mentioned before, and the *lasso* The lasso consists of a rope made of strips of untanned hide, varying in length from fifteen to twenty yards, and about as thick as the little finger It has a noose or running knot at one end, the other extremity being fastened by an eye and button to a ring in a strong hide-belt bound tightly round the horse The Gaucho gathers the lasso in a coil before he discharges

it The coil is grasped by the horseman's left hand, while the noose, which is held in the right hand, trails along the ground, except when in use, and then it is whirled round the head with considerable velocity, during which, by a peculiar turn of the wrist, it is made to assume a circular form, so that when delivered from the hand the noose preserves itself open till it falls over the object at which it has been aimed. It is astonishing with what dexterity the Gauchos use both the bolas and the lasso, on horseback and at full gallop, and how they hit with unerring precision the object aimed at. They use them, especially the lasso, not only in hunting, but also in catching the cattle and horses which wander about the plains in an almost wild state A long carving-knife, about fourteen inches in length, placed in a leathern sheath, which is stuck in his girdle or leggings, completes the Gaucho's equipment, and thus mounted on his good steed he is lord of all he beholds. He owns no master, tills no ground, hardly knows what a government means, and does not care for it His wants and desires are few, and he has always within his reach wherewith to satisfy them. A Gaucho on horseback affords a noble sight His elevated head, his upright and graceful air, the rapid movements of his well-trained steed, all concur to convey a true picture of a man perfectly independent. He resembles more a Tuarick of the Sahara than a Spaniard, thus similar circumstances form similar characters both in nations and in single individuals

The huts of the Gauchos are small and square, with a few posts for uprights, and wattled with osier-twigs plastered over with mud, and sometimes merely protected by hides The roof is thatched with straw or reeds, open in the centre to permit the smoke to escape A few blocks of stones, or the skull-bones of horses, serve for seats, a small table, about eighteen inches high, to play cards upon; a crucifix hung on the wall, and sometimes an image of St Antonio, or some other patron saint, complete his furniture. Sheep-skins for the women and children to lie upon, and a small fire in the centre,

are his only luxuries The Gaucho, when at home, is either sleeping or gambling. A few fruit-trees are occasionally planted near the hut.

The Gaucho women dress in chemises of coarse cotton, and petticoats of baize or blue cloth, their arms and neck are left bare When they ride out they wear scarfs or shawls made of baize of a brilliant colour, and men's hats, either of straw or woollen They sit sideways on horseback, and are as good equestrians as the men. The women are the labourers It is they who cultivate a little Indian corn, which serves them for bread, they also raise water-melons and onions, and weave coarse baize and ponchos, but their lives are idle on the whole, and they are more remarkable for dirt than cleanliness Their cooking utensils are usually of clay, and their platters of wood.

The western part of the Pampas of Buenos Ayres, or that which extends between 66° W long. and the base of the Andes, presents a less level surface The soil consists of loose sand impregnated with saline matter, and is entirely unfit for the growth of grass The vegetation is limited to low thorny trees, standing isolated and at considerable distances from each other, some resinous bushes, and barilla plants. This country in its natural state is not unlike some tracts of the Sahara But this arid soil, when irrigated, is changed into the most fertile fields The saline matter, as it seems, when applied to a soil so light, becomes by the assistance of constant moisture a most active stimulant to vegetation, and serves as a never-failing manure It is fortunate for this region that it is drained by several rivers, and that their levels are so little depressed below the general surface of the plain, that their water can be applied to irrigation without any great labour and expense. Indian corn and wheat are grown to a great extent. The soil seems particularly adapted to fruit-trees, and plantations of vines, figs, peaches, apples, olives, and nuts, are very numerous and extensive

The rivers which water this country deserve a particular notice They constitute a separate system of

drainage, which is not connected with the sea, nor with any rivers which run to the ocean. Such closed systems of drainage are found at several places on the globe, but they are usually of small extent. The system we are now speaking of, however, is so considerable, that only one is found, in the centre of Asia, comprehending a larger space of the globe The rivers of the Pampas, which constitute this remarkable system of drainage, rise in the Andes between 31° and 36° S. lat They run eastward, and when they have traversed a considerable part of the plain, they unite their waters in three groups of lakes, which from north to south are called Guanacache, Bevedero, and Urre Lanquen These lakes are placed at various levels above the sea, the most northern being the highest, and the most southern the lowest Thus it happens that a river, the Desaguadero, runs from the lakes of Guanacache to those of Bevedero, and another, the Rio Salado, from those of Bevedero to Lake Urre Lanquen. All these lakes, however, have salt water, and their margins during the winter and spring are covered with incrustations of that mineral. Some of the rivers are also brackish, and their waters cannot be applied to irrigation, but others have fresh water, and to these the country owes its fertility and abundant crops

In the middle of the great plain, the southern part of which has just been described, a mountain-system of small extent is found. It is called the Sierra de Cordova, from a town built near its eastern base It occupies from south to north about 120 miles, lying between 32° and 30° S lat, and from east to west about 50 miles, so that its area does not exceed 6000 square miles This mountain-system is composed of several ridges running south-east and north-west. These ridges are flat on the top, which is clad with fine grass and affords good pasture The greater number of the valleys between them are fertile, and partly cultivated, being partially covered with plantations of vines and fruit-trees. The ridges do not rise to more than 2500 or 3000 feet above their base, consequently snow does not fall on them except during two or three months. If the moun-

tains rose to a greater height, and were covered with snow the greater part of the year, they would supply the adjacent countries with running water all the year round, and would convert them into agricultural districts. Still, even as it is, it is evident that the pastoral pampas above mentioned as the country of the Gauchos, derive great advantages from the snow which falls on the Sierra de Cordova. For the water which in winter time covers the lower tracts of the country and converts them into temporary swamps, is brought down by the streams, which in summer are dry, but by the melting of the snow have their deep beds so filled that they resemble large rivers. The grass which grows in the swampy grounds when the water has been evaporated by the long drought of the summer, affords subsistence to the cattle during that portion of the year when everywhere else the grass of the pasture-grounds has been parched up. Without these low pastures all the herds of cattle and horses would perish, and the whole country become as uninhabitable as is that portion of the great plain which lies contiguous to the Sierra de Cordova on the north. For by a peculiar disposition of the mountain-ridges all the waters collected within them run off either to the south or to the east, fertilizing these parts in a greater or less degree, but none of its numerous though scanty water-courses descend to the north or west, and those countries have remained useless wastes to this day, and will probably always be found to be so.

The northern and worst part of this plain is known by the name of *Las Salinas*, or the Salt Desert. The only traveller who has traversed this tract and given an account of his journey, Mr French, describes it as follows:—"The morning was ushered in by a cloudy mist, through which the red sun gradually rose, partially dispersing the upper vapours, while others appeared to resist his influence, and, attracted to the earth, remained dense and motionless near its surface. As we entered the Salinas the scene became novel and striking. The wide plain, level and smooth as a floor, and snow-white with superficial salt, stretching its treeless and

shrubless waste on all sides to the horizon, unbroken by any object, save a few stunted, straggling, and leafless alkaline bushes, the black and crooked branches of which, contrasting with the whiteness of the soil, were here and there hid and intersected by a broad, compact, and very thin stratum of mist, whose under-surface was slightly elevated from the soil, while its upper was below the tops of the bushes, thus permitting only their stems and tops to be recognised This was the *mirage*. Over head rolled thick and broad masses of transparent white vapour, which, except at intervals, hid the sun without greatly intercepting his light, and when his rays shot between these masses, they were reflected from the space on which they fell by the saline superficies of the soil with a dazzling effulgence. Such was the appearance of the vast salt plains at the time we crossed them, in the middle of April Great changes, however, are produced by a variation of circumstances I have myself observed the most astounding change in the appearance of a portion of the plain after sudden rain succeeded by a hot sun In a region where a slight saline efflorescence is ordinarily seen, the ground became almost snow-white from the rapid crystallization of saline matter, and reflecting the rays of a fierce sun, rendered it most difficult to keep the sight fixed on the road-track The landscape appeared in one blaze of reflected light; trees and shrubs seemed on fire, and the whole scene might have been taken for the land of the genii, while the hot north wind, called the *sonda*, rose by degrees and in squalls to a gale, with a close heat, like that of a furnace In this instance nothing in the shape of a cloud or mist was present" The same traveller found the plain, on approaching the Andes, in part overgrown with wood, and in part without trees and even shrubs; and observes that the most remarkable feature of this region is the great scarcity of water and the total absence of grasses, particularly of the kinds fit for cattle Over tracts, wooded or unwooded, not a blade of grass is to be met with All these countries, which are distinguished by the name of *traversias*, have a very dry air

and are characterized by great aridness. In some parts of them rain has been known not to fall for eighteen months. Dews are entirely unknown. The slight humidity afforded by the general state of the atmosphere appears to be drawn off towards the Salinas, and absorbed by its saline soil, which thus exhausts the atmospheric moisture, so as to render unproductive of grass regions possessing a soil favourable for its growth. The Salinas are almost the only places in which, under ordinary circumstances, any moisture is apparent, and in these vegetation becomes extinguished by the excess of nitric and muriatic salts, with the exception of a few scattered saline and alkaline shrubs.

It is doubtless to be ascribed to the vicinity of the Salinas, that Santiago del Estero, which is built on the banks of the Rio Dolce in their vicinity, experiences a greater degree of heat than any other place in America, though that town lies without the tropics (28° S lat.). The month of December is always excessively hot, but this heat is sometimes greatly increased by a hot wind blowing from the Salinas. It blisters the skin on the face and hands even of those who remain in-doors. Leaves fall scorched from the trees, and the bark of several of them become cracked and shrivelled, just as if the heat of a fire had been applied. Even at night the locks, bolts, and keys of apartments are so hot that they cannot be retained in the hand, and it is hardly to be comprehended how they can have acquired such a degree of heat without artificial aid. The description which the inhabitants give of their sufferings and their feelings, under the apprehension of suffocation, are quite appalling.

The Salinas extend about 200 miles from east to west, and 140 miles in the opposite direction. Here, therefore, in South America, is a tract of country, as extensive as Ireland, which may be compared with the worst part of the Sahara. It is certainly a most remarkable circumstance that, north of this desert plain, the country rises into hills, which gradually attain the elevation of mountains, and, at a distance of about seventy miles from its northern border, reach above the snow-line in the

Sierra de Aconquija. Several rivers originate in this mountain tract, but they have very little water, and are lost in the ground on approaching the Salinas. It appears that the great aridness of the atmosphere, incumbent on the desert and the adjacent regions, prevents the collection of any large quantity of water in the mountains.

What a contrast with the Salinas is afforded by another desert, which lies only about two hundred miles north of it, and called the Despoblado, or the Uninhabited Country! This is an extensive plain, occupying the very top of the Andes, and stretching from east to west between 69° and 68° W. long., more than 250 miles, whilst its width gradually increases to 150 miles at the places where the mountain-masses descend towards the Pacific. The elevation of this plain has not been determined, but it is very probable that it rather exceeds than falls short of 13,000 feet above the sea-level. As in these parts of South America the snow-line appears to occur at an elevation of about 14,500 feet, the surface of the Despoblado is only 1500 feet below it, and consequently above the line where trees and bushes grow. This region is divided from south to north by a deep valley, through which the road runs which serves as a line of communication between Buenos Ayres and Bolivia. This valley has been an object of admiration to all travellers who have passed along it, on account of its great length, comparatively small width, and the steepness with which the rocks rise on both sides. It is more than 150 miles long, and at many places hardly a furlong wide. Nearly in its middle the town of Jujui is built. North of that place the bottom of the level rises gradually until it attains the elevation of 12,000 feet above the sea, where it is shut up by a transverse ridge, the Abra de Cortaderas, which unites the two portions of the mountain-plain. The eastern and smaller portion is called the plain of Yavi, and the western and larger bears properly the name of Despoblado. The degree of cold which a traveller experienced in June during a storm, accompanied by snow,

hail, and sleet, on the plain of Yavi, can hardly be surpassed by that which persons have to endure who spend the winter at the North Cape, and the climate of the Despoblado is certainly not less severe. These plains are, however, not uninhabited. Several small hamlets are found on them, in each of them reside a few families of natives, who belong to the race of the native Peruvians. They have no cultivation nor domestic animals, except llamas But on the plains are numerous herds of alpacas, vicuñas, and guanacos, as also that little beautiful animal, the *chinchilla* This last is so common that thousands of dozens of its skins are yearly collected and sent down to Buenos Ayres for exportation to Europe. The inhabitants collect also considerable quantities of gold, which is found in some of the alluvial deposits after heavy rains They also bring snow to the places situated in the valley of Jujui, where it is used for making ices in the summer season. But one of the most curious features of the Despoblado is its extensive plains of salt, and they afford great advantages to the poor inhabitants, who resort to them when the salt is hard and dry, and cut large blocks of it with hatchets, with which they load their llamas, and carry them to Jujui and Salta, and other parts of the country. The eyes of travellers obliged to traverse these inhospitable wilds are said to be as much affected by the glare of the sun reflected from these fields of salt, as from the snow-capped mountains which surround the plain The Despoblado lies for the greatest part of its extent within the tropics, extending between 22° and 24° S lat.

Section XIV.—The Llanos

The forest-desert of the Amazonas extends northward until it is succeeded by the Llanos (plains) of South America These plains have a surface as level as the most even part of the Pampas, but as they are situated within the tropics they present a wide difference in climate, soil, productions, and the life of man. Their extent, however, is much less than that of the Pampas, as their area amounts only to about 350,000 square miles, and is not quite equal to twice the extent of France

The Llanos are situated on the left banks of the Orinoco, one of the largest rivers of South America. This river, whose source has not yet been visited by Europeans, rises in a mountainous country situated only three or four degrees from the equator, on the northern side of the line, and flows first westward for about 350 miles, then northward for nearly the same distance, and lastly eastward for nearly 500 miles. Its course describes nearly a semicircle, and its mouths are found to lie to the east of its source, though the direction of its upper course is westward. This river is navigable as far as it is known, except a space of about forty-five miles between 5° and 5° [illegible]0′ N lat, where the *raudales* of Maypures and Atures break the continual smoothness of its current. These raudales are cataracts of a peculiar description The great volume of water brought down by the river does not descend at once from a considerable height, as in the Niagara river, nor does it, as in the Amazonas in the Pongo de Manseriche, traverse a narrow opening between high rocks, but the bed of the Orinoco at Maypures and Atures, where it is nearly 8500 feet wide, is divided into numerous narrow channels by rocks and

rocky islands, between which the water runs with great rapidity, and forms a succession of small cascades. The highest of these cascades does not exceed nine feet, and the river descends, in about six miles, only about thirty feet by all the cascades of the raudales of Maypures; but the velocity with which the confined body of water runs in the narrows precludes the possibility of ascending the cataract. The Raudali of Atures is only half a mile long, and of a similar description.

About 130 miles from the place where the waters of the Orinoco mingle with those of the Atlantic, the river divides, and sends off its waters in several channels, which again split on approaching the sea, so that the waters of the river enter the ocean by a great number of mouths. Ten of these mouths are wide rivers, and deep enough to be navigated by large vessels; but the most southern arm, called the *Boca de Navios*, contains the largest volume of water. It is divided, for a distance of about forty miles, into two channels by a series of islands which lie nearly in the middle of the stream. Each of these channels is more than two miles across, and the whole width of the river, inclusive of the islands, considerably exceeds five miles. Farther down, its breadth continues to increase, and at the mouth the river is more than sixty miles across.

The country which is included within the several mouths of the river, extending about 130 miles from east to west, and nearly 100 miles from south to north, is the delta of the Orinoco. This tract is entirely inundated during at least six months of the year, when the volume of water has increased to such an extent in the river that its wide and numerous channels cannot contain it; it then spreads over the adjacent lands, and all the tracts which lie between the different channels. In the other six months, when the water has retired to the bed of the river its banks are several feet above its level, and dry; but farther inland the ground is not entirely drained, and the largest portion of the tracts between the arms of the river are little better than swamps. Though the delta of the Orinoco is entirely inundated during one

half of the year, and almost a continual swamp during the other half, it is not uninhabited. A native tribe (the Warrows, or Guaraunos) has established itself in this region. It lives partly on the produce of its fishery in the arms of the river, and partly on the fruits of the fan-palm; for though the delta of the Orinoco, like the country on the banks of the Amazonas, is covered with uninterrupted woods, there is this difference, that the woods of the delta are almost entirely composed of one species of tree (the fan-palm), which by a Spanish author has been called the tree of life, because it supplies both food and clothing. The pith of this tree gives a kind of flour, of which bread is made, its head is eaten as a vegetable, from its fruit a kind of wine, of an acid taste, is extracted, the fibres of its leaves are used as thread, of which hammocks, baskets, and tissues for dress are made; its wood is used in the construction of their huts, which are thatched with the entire leaves of the tree. During the inundations the Warrows live on scaffolds, which are erected between the trunks of the high trees several feet above the usual level of the water, which circumstance has given rise to the opinion that this tribe lived in trees. These Indians have acquired, by long habit, a great facility in running over muddy lands, where other persons sink up to their knees; and by this peculiarity they have preserved their independence, as none are inclined to follow them in their retreats. They are good seamen, and do not possess that ferocity of character by which most of the tribes on the Amazonas are distinguished.

The delta of the Orinoco is the only portion of the p[illegible] we are now noticing which is wooded; all the remainder of this extensive region is devoid of trees. Contiguous to the delta is that portion of the plains which is called Llanos Altos, or elevated plains. It extends from the northern banks of the Orinoco northward, and reaches the shores of the Caribbean Sea on both sides of the town of Barcelona, but farther to the east it is divided from that sea by the mountain region called [illegible]ierra del Bergantin, and farther west by the coast range

of the Andes. The Llanos Altos extend about 350 miles from east to west, and more than 200 miles from north to south. They are less level than the remainder of the plains. Along the banks of the Orinoco they are both level and low, and the river spreads its waters, during the inundations, to a distance of many miles from its banks Farther north the country rises, but imperceptibly to the eye, for at a distance of more than 100 miles from the Orinoco the level of the plain is not more than 500 feet above that of the sea. The rise of the country, however, is apparent from the course of the rivers, which run in beds depressed several feet below the general level of the plains. The highest part of this plain is from 500 to 800 feet above the sea, and is a complete level from 30 to 40 miles across Towards the Caribbean Sea it descends with a somewhat more rapid declivity, but even this is imperceptible to the eye, except at a few places The summits of the table-lands thus formed are known by the name of *mesas* (or tables), on account of their level surface Their soil consists of sand, in many places mixed with chalk. It is unproductive; and the vegetation, even in the rainy season, is limited to a few hardy grasses covered with a kind of hair, which afford but indifferent pasture. The rains, which fall in abundance from April to July, do not impart fertility, as on the other portions of the Llanos, because they quickly find their way through the upper layers of the soil until they meet an argillaceous chalk, where they collect and form springs and rivulets. The mesas themselves are always without water, and the traveller must perish of thirst on these high grounds if he does not carry water with him, yet these very table-lands give origin to a hundred rivers, which run off on all sides To the greater part of this region nature has denied the power of producing grain and edible vegetables; only its southern and northern borders, along the banks of the Orinoco and the shores of the Caribbean Sea, are cultivated, and those only at a few places where cotton, coffee, cocoa, sugar, tobacco,

and several tropical roots and fruits are raised, with cassada, yams, bananas, &c.

The larger and more level portion of the Llanos extends from north-east to south-west, and lies along the base of the elevated rocky masses of the Andes, from 9° N lat. to the equator, where it is stated to terminate on the upper course of the Yapurá, an affluent of the Amazonas. Though placed at a greater distance from the sea, they are much lower than the Llanos Altos. The lowest tract is found near the junction of the river Apure with the Orinoco. Its level is only 224 feet above the sea, though more than 500 miles distant from the ocean, to which the waters collected on it descend. To the south, however, and to the west, the country ascends imperceptibly, but it is supposed that at no place does it rise more than 300 feet above the lowest tract just mentioned. These plains are so level that the currents of the Apure and Meta rivers, in their lower course, are imperceptible, and a strong eastern gale, or the least rise in the Orinoco, causes their waters to flow back. The native tribes who navigate these rivers maintain that, in proceeding from the Orinoco up these rivers, the first day's voyage is with the current. In these plains no rock, no stone, nor even a pebble is seen. They are covered with grass, but entirely destitute of trees and bushes, except a number of isolated palm-trees, which occur at great distances from each other. On the banks of the rivers, at many places, are thickets of low bushes, but in general no wood is seen even there. The only inequalities of the surface are some hills, merely of sand, which rise a few yards above the common level, and some [illegible]ly elevated grounds called *banks*. These banks are sometimes of great extent, having an area of 100 square miles and more; but their elevation is so small that only a practised eye can distinguish it, and their surfaces are completely flat. They are of great importance to the inhabitants, as most of them are not subject to inundation, and consequently afford places for building, and pasture for the cattle, when the lower parts are covered

with water The soil of these plains has not much depth, and consists of a mixture of sand and chalk, mixed up with some mould The grass which it produces is very nourishing at most places, though at others the pasture-grounds are but indifferent

In the Llanos, as in all other countries between the tropics the year is divided between a dry and a wet season, It is very probable that the changes in the atmosphere, by which these variations in the climate are produced, are more regular in these plains than at any other part of the globe The great extent of the plains, and their low and level surface, permit the currents of the air to develope themselves without the least obstacle. At most other places this process of nature is prevented, or at least influenced or changed, by mountains, or the vicinity of the sea, or by a broken and uneven surface. In all such places the regularity of the phenomena attending these changes is interrupted or mixed up with other phenomena, which arise from causes not connected with their regular process It is true that along the western side of the Llanos the Andes rise to a great elevation, and at some places above the snow-line, but as these mountains extend in their general direction from south to north, or from south-west to north-east, they do not lie in the way of the principal currents of air, which depend upon the position of the sun and its march from the southern to the northern hemisphere, or in the opposite direction It is, therefore, supposed that these mountains do not materially influence the changes of the season and the phenomena with which they are attended. The mountains of Venezuela, both the coast-range of the Andes and the Sierra del Bergantin, may certainly affect the free development of the aerial currents in their vicinity, but they are of too small extent and not elevated enough to have any material effect on a level plain which extends to nearly six hundred miles from their bases As on these plains, therefore, the two seasons and their changes are less influenced by localities, Alexander von Humboldt has examined all the phenomena with great attention, and endeavoured to give an explanation of them.

Nothing can be compared with the purity of the atmosphere from the month of December to that of February The sky is always serene and cloudless, if a cloud appears, it is a phenomenon which attracts the attention of all the inhabitants. The wind blows from the east and east-north-east with force. As it brings to the plains an air which is always of the same temperature, the vapours cannot be condensed by cold, and cannot become visible Towards the end of February and the commencement of March the blue colour of the sky is less intense, the hydrometer indicates a gradually increasing humidity of the air, the stars are sometimes enveloped in slight vapours, so that their light is not steady, but is observed from time to time to sparkle, until they rise to an elevation of more than 20° above the horizon At this period of the year the wind blows with less force, and is less regular, being from time to time interrupted by dead calms Clouds begin to make their appearance and to accumulate in the south-east They resemble distant mountains, their edges being well defined. From time to time some of them are observed to rise above the horizon, to detach themselves from the others, and to traverse the celestial vault with a rapidity which is by no means in proportion to the feeble winds experienced in the lower regions of the atmosphere At the end of March small electric explosions are observed to occur in the southern regions of the atmosphere They appear like phosphorescent lights limited to an isolated group of vapours Then also the wind passes from time to time, and for several hours, from east to west and to south-west. This is a certain sign that the season of rain is approaching, which actually sets in towards the end of April on the banks of the Orinoco. The sky begins to be overcast, the blue colour disappears, and is replaced by a grey coating, which has everywhere an uniform appearance. Meantime the heat of the atmosphere is continually and gradually increasing. In a short time they are no longer clouds which envelop the sky, it is a strongly-condensed vapour. During the dry season, from December to February, the electricity of the atmos-

phere hardly undergoes any change, varying in day-time only between one-third and two lines of the electrometer of Volta, but in the month of May it becomes very variable. During whole days it is nil, but at times, and for several hours, the elder-balls of the electrometer of Volta diverge three or four lines. The season of the rains is also that of thunder-storms "But," says Humboldt, "a great number of experiments which I made during three years have convinced me that just during this season of the thunder-storms, the electric tension is very small in the lower regions of the atmosphere. The thunder-storms begin two hours after the sun has passed through the meridian, consequently very little time after the highest degree of heat is experienced between the tropics It is very rare to hear the thunder during the night or in the morning. The nightly thunder-storms occur only in certain valleys of rivers which have a peculiar climate"

The setting-in of the rains and thunder-storms takes place when the sun passes through the zenith, which occurs between 5° and 10° N lat, between the 3rd and 16th of April, and is attended by a cessation of the north-eastern wind, frequent calms, and occasional south-western winds, accompanied by storms and an overcast sky It appears that the first of these phenomena, the cessation of the winds, affords a clue to explain the whole process Whilst the north-east wind blows with all its force, it prevents the air incumbent on the intertropical countries and seas from becoming saturated with vapours. The humid air of the torrid zone, rarefied by the heat, rises into the upper regions of the atmosphere, and there flows off to the poles, whilst the lower currents, proceeding from the poles, bring to these places a much drier and colder air, which continually replaces the columns of air which ascend from them As long as this process continues without interruption, the moisture, so far from being accumulated in the countries near the equator, is carried off towards the temperate and cold regions During the north-east winds, which blow when the sun is in the southern hemisphere, the sky is

always cloudless in the intertropical countries of the northern hemisphere The vapours do not condense, because the air is always replaced by other air far from the point of saturation But when in progress of time the sun enters the northern constellations, the north east wind abates gradually, and at last ceases to blow The difference of temperature between the intertropical countries and the temperate zone is then less than at toher periods of the year This is the summer in the northern hemisphere, and the mean summer heat, experienced between 42° and 52° N lat, is only from 7 to 10 degrees less than that of the intertropical countries, whilst in winter the mean heat differs from 36° to 46° When the sun is in the zenith and the wind ceases, the causes which produce and accumulate the humidity of the air of the equatorial zone become more active The stratum of air which is incumbent on these countries by degrees becomes saturated with vapours, because it is not renewed by the current from the poles Then clouds are formed in this saturated air, by condensation produced by the combined effect of the radiation and dilatation of the ascendant air This air increases its capacity, from being heated in proportion as it becomes more rarefied With the formation and accumulation of the vapours the electricity also accumulates in the upper regions of the atmosphere At last the precipitation of the vapours takes place, and the rains continue during the day-time. They cease commonly during the night, and frequently at sunset The rains are in general most heavy a little after the greatest degree of the diurnal heat is experienced, and then they are attended by electric explosions. This state of the weather continues until the sun returns to the equatorial line, and re-enters the southern hemisphere. The atmosphere of the northern temperate zone then rapidly grows colder, and in consequence of this event the current of air proceeding from the northern countries to those between the tropics again makes its appearance, because the difference between the temperature of the intertropical and temperate countries is continually increasing The north-east wind again blows

with force, the air between the tropics is continually renewed, and cannot longer attain a high degree of saturation The rains consequently cease, the vapours dissolve, and the sky resumes its purity and deep blue colour.

After the commencement of the rains, the waters of the rivers begin to rise, and after a few weeks, their beds are not capacious enough to hold the large volume which gathers in them They rise above their banks, and inundate the low countries bordering on them The inundations extend to a considerable distance from the banks of all the larger rivers, and in some cases the tracts which lie between them are entirely laid under water There is a large tract of low country where the Orinoco changes its northern into an eastern course, which extends on both sides of the river Apure This tract, having an area of 4800 square miles, is converted into a temporary lake, the water covering it being from twelve to fourteen feet deep The villages and cattle-farms, which are built on small banks, are raised scarcely two or three feet above the level of the lake Many horses which wander about in the pasture-grounds perish, being unable to get on the more elevated points of the plain when the waters are rapidly rising The mares, followed by their foals, swim about to get to the grass, the tops of which only are above the level of the waters, and a great number of the foals are drowned because they sooner tire in swimming, and follow their mothers into water too deep for their height When thus seeking their safety, these animals are frequently attacked by the caymans, which swarm in most of the rivers · and horses are frequently met with, whose legs are marked by the teeth of these reptiles. At this season large barges traverse the plain, where six months later numerous herds of cattle, horses, and mules, find abundant pasture

When the waters have begun to draw off, and the rivers are again confined to their beds, the higher tracts of the plain become dry and firm, and are covered with a fine turf, interspersed with aromatic flowers The animals, which at the end of the dry season, and during the

long inundations, had become very lean, are soon in good condition. As the dry season advances, this grass attains a height of from five to eight feet, and becomes hard and unpalatable for the animals, but at that time the lower grounds, which for some weeks longer had remained in a swampy condition, are clad with a fine short grass, which is very nourishing. But towards the end of the dry season the grass becomes so extremely course, that it is unfit for cattle, for it then more resembles dry reeds. If this grass was to remain on the ground, it would prevent the young grass from springing from the roots of the old, as it does immediately after the first rains. It is, therefore, necessary to burn it down. To effect this the natives set fire to it at different points, producing a conflagration which extends over many square miles, and affords a magnificent spectacle when seen from a distance. The rapidity with which the volumes of fire are driven on by the wind that constantly prevails at that season in these level plains is terrific, and threatens certain destruction to every living being that is unfortunately surprised by it. There is, however, generally sufficient warning afforded by the clouds of smoke that arise from the conflagration, giving the sun a lurid appearance. In the rear of the flames, the track of which is marked by the smoking roots of grass and the blackened soil, follow flocks of vultures and *gallinazos*, which find abundant subsistence, as long as the fire lasts, in the multitude of snakes, bull-frogs, and other small animals, which have been overtaken by the flames and scorched to death. In this season, also, the caymans, inhabiting those places, which only dry up towards the end of the season, make a hole in the mud which remains, creep into it, and cover themselves with moist earth, falling into a lethargy, which only ceases when the rains set in, and fill the depressions again with water. The domestic animals fare badly for food, but still worse for drink, in such places as are distant from running streams. There are usually some places where stagnant water is still left, but the natives are too lazy to look for them; and to make a well, which is no labo-

rous work, as the water is always found at a depth of a few feet under the surface, is hardly ever attempted. They compel the animals themselves to find out the stagnant waters, for which purpose they keep them penned up for some time, and then let them loose. The animals run against the wind with raised heads and open nostrils, and commonly succeed in finding out such places by the comparative humidity of the air in their vicinity The asses show the greatest sagacity in this respect In many places a kind of cactus is found, which is beset with thorns, but contains in its stem a quantity of water The asses crush these plants, and sip its contents with caution, but many of them are lamed by the thorns

The heat towards the end of the dry season is very great, the thermometer rising in the shade at two o'clock to 97°, and when exposed to the sun's rays to 125° But it increases up to the month of July, when the thermometer, at two o'clock in the afternoon, ranges between 102° and 105° in the shade and fifteen feet above the ground As the surface has lost all its moisture by evaporation, and the north-eastern wind is still blowing in March, it raises such a quantity of dust that it is almost impossible to find one's way, especially when the wind blows in whirls The plains then offer a most sombre aspect, as the whole of them present nothing but a complete desert, consisting of brown sand, the trees and bushes having then shed their leaves, and the grass being entirely dried up but it is stated that the trees begin to unfold their leaves before the first rains set in

The want of wood is not felt by the inhabitants, as their climate does not render it necessary as fuel, and for their domestic uses they have a substitute in the *guadua*, or South American bamboo, which abounds in many parts, forming rather large groves along the banks of the rivers. This is a gigantic species of cane, growing to the height of ninety feet and frequently even more, with a beautiful feathery appearance The upper part bends gracefully downward, and is covered with long slender branches, which spring from the joints, and

bear very small light leaves. This cane is extremely useful for the purpose of building houses and bridges, as well as for fencing plantations, and surrounding the *corrals* or cattle-pens, as it resists the weather for many years. The thickest parts serve for posts, beams, and rafters. They are also formed into broad planks, by being split open longitudinally with an axe, and spread out by cutting through the alternate joints at sufficient distances to allow of their hanging together. In this state they answer very well for roofing and for flooring the upper story, which is that which is generally inhabited in the marshy districts. The guadua also serves for making bedsteads, tables, and benches, which are both light and neat. The walls of the houses are made of the small branches tied closely together, fastened with thin thongs of raw hide, and plastered over with clay. The thickest canes, being frequently eight or nine inches in diameter, are made into buckets by cutting off joints for that purpose. Small barrels are also made in the same way. The guadua is also in great demand for building bridges across the narrow rivers in the plains.

In no part of the world is the electric eel found in such numbers as in the numerous rivers which join the Orinoco in its middle course, and in that river itself. These animals resemble a common eel, except that they are rather thicker in proportion to their length. They are of a yellowish and livid colour with a row of yellow spots on each side from head to tail. They are difficult to catch, on account of the great agility with which they hide themselves in the mud. The Indians take them in the following way. They force a herd of horses to go into shallow water, which they know to be frequented by these eels. The noise which the horses make with their feet brings the eels out of their muddy retreat, and they immediately attack the horses, by pressing themselves beneath their bellies and discharging on them their electric shocks. The frightened horses make efforts to get out of the water, but the Indians prevent them, and the eels repeat their discharges. Some of the horses

being stunned by these repeated strokes, fall down and are drowned. Others evince all the signs of horror, and endeavour to escape, but are prevented by the Indians. At last the eels are exhausted, in consequence of the repeated electric discharges, and are easily taken The shock which these animals communicate is so severe that it is impossible to hold them in the hand or to tread on them. They can give a shock exactly similar to that of an electric battery, stunning fish through the medium of water, and if they are small, killing them. This shock is evidently given by a voluntary act of the fish, for it is not always felt instantaneously on handling them; and the moment of the effort being made can be distinguished by the corrugation of the skin and the changing of its colour. The most remarkable of the other inhabitants of the rivers are the manatee, or sea-cow, and a kind of dolphin, whose species has not yet been determined, and which is the only one of the whole family found in fresh water These fish are from three to four feet long, but so active that they are feared by the cayman, probably because they are only met with in large numbers, one swimming behind the other.

The wild animals are not numerous; except a kind of deer, which is very slow and not much sought after, because its flesh is not valued, and a species of agouti. The American tiger, or jaguar, and the American lion, or puma, are sometimes met with, when the grass is high, and these animals, especially the first, destroy large numbers of domestic animals. The chiguiris are a kind of amphibious river-hog, having very short ears and no tail, but in other respects resembling the pecari, or wild hog of the woods. These animals are found in droves in the marshes and on the borders of the lagoons, to which they retreat on any alarm. Their flesh is tender and fat, but has a strong fishy taste It is stated that at present there are no wild cattle nor horses which have not a proprietor, but there are wild asses, wild hogs, and wild dogs, whose ancestors were domestic. The wild dogs have increased at some places so much as to be dangerous to small parties of travellers, being of the

breed of a fleet and ferocious dog, which is much valued for protecting the cattle against the attacks of the jaguar and puma

That part of the Llanos which is not subject to inundations was not quite uninhabited at the arrival of the Spaniards, a few families of a native tribe having settled there, whilst others visited it occasionally But the lower Llanos had no settled inhabitants For the Indians, having no domestic animals except some birds of the fowl kind, were unable to procure subsistence during the six months in which the country is under water Some Spaniards, settled in the mountainous country north of these plains, discovered them, and soon became aware of their value as pasture-grounds. In the middle of the sixteenth century they brought some horses, cattle, and asses to them, and these animals have so increased in number, that it is stated they amount at present to more than three millions With these animals the Spaniards emigrated, and up to this time they are the only inhabitants of the Llanos, with the exception of a few families of Indians of different tribes, who have settled among them, and a still smaller number of negroes As the descendants of the Spaniards have no other occupation but to tend the domestic animals, to kill them and dry their hides, and to break-in the horses, their number is but small The cattle-farms are at a distance of a day's march and more from each other, to allow sufficient range without interference for their respective herds of cattle As there are no roads in these plains, it is very difficult for a stranger to find his way from one farm to another The inhabitants guide themselves by the clumps of palms, which are to be seen at considerable distances apart, giving the idea of small oases in the desert.

The cattle-farms are called *hatos* The houses attached to them are built of guadua they are of one floor, consisting in general of a large hall, the walls of which are hung round with saddles, bridles, and lassos The furniture commonly found is limited to a large table and several long massy benches too heavy to be

moved. In the hall the inmates eat when driven in by the rain, and there also the males belonging to the farm sleep in bad weather They lie down on undressed bullocks' hides spread over the benches, but these places of rest are by no means softer than the earth There is also a separate apartment or two for the females' use in the rainy season In the dry season all sleep in the open air on account of the heat The neighbourhood of the corral is preferred as a protection against the *zacudos*, a kind of gnat which is very troublesome, but prefers attacking the cows The male inhabitants have more abandoned the usages of civilized life than the females. This is especially conspicuous in their dress The men go stark naked, except a cloth of cotton which is wound round the loins, like the savage tribes on the Amazonas But the women have only changed their dress so far as it is rendered necessary by the peculiar climate of the Llanos Their food is extremely simple, consisting every day of roast beef, cheese, and milk, to which they add brandy as drink, but never in such quantities as to be inebriated Bread is extremely rare, except on the plains bordering the higher country, where grain is cultivated. At some places on the banks of the river, however, small plantations of plantains or cassada are met with. In some parts the sugar-cane is cultivated, but though it grows well, it runs more into leaf than that planted in the hilly country, is thicker, and gives more juice, though less saccharine matter in proportion. Some is cultivated only for chewing, but in general a very coarse kind of sugar is made, and the greatest part is used for distilling that kind of spirit which is used in the country and called *aguardiente*

As there are, of course, no inns in these plains, hospitality is exercised to the greatest extent, and a traveller resorting to a farmhouse is considered as conferring an obligation on its proprietor. His horse is immediately unsaddled and turned loose, for it is quite a matter of indifference whether they stray or not, as there are always plenty of horses close at hand, which are considered as public property Water is then brought to

wash the stranger's feet, after which he spreads his cloak or blanket in the shade, and lies down, using his saddle for a pillow. Meanwhile one of the family has already saddled a horse and set out in search of a calf or a young heifer, for which they have seldom far to ride; indeed they generally keep one tied up in the corral in readiness for daily use, as meat will not here keep good for a day after being killed. In less than half an hour an abundance of roast beef is set before the visitors, and sometimes, but very rarely in the remote cattle-farms, some bread. The repast concludes with milk, cheese, and aguardiente.

Their occupations, as well as their ideas, lie within a very narrow compass. Two or three, on horseback, look daily after the cattle, and bring those back which have gone astray, they bring also the milking cows to the corral. The other inmates of the farm are mostly idle, except in the season of slaughtering the cattle, when all are busy, either in drying the hides or in jerking the beef The most laborious part of their business is the breaking-in of the wild horses, in which they display great dexterity, firmness of mind, and courage.

Passing their lives on horseback, the llaneros have acquired an extraordinary skill in managing their animals. In this respect they greatly surpass the Cossacks of Russia and the Tunguses of the Chinese army, and are the best irregular cavalry that can be imagined. They can hang on the sides of their horses while at speed, directing them by voice and rein, and sheltering themselves in this way from the lances, balls, or shots of their adversaries At a distance a troop of such horsemen advancing irregularly may be taken for loose horses, of which so many are seen wandering on the plains. They can even cling quite beneath the belly for a short time, still urging and directing their horses. In the war by which Venezuela obtained its independence their services were of great use to the patriotic armies.

Their constant exposure to the open air and prevalent heat has hardened their bodies to an extraordinary degree.

It is remarkable that these llaneros can travel, in a slight dress, over the Andes to the towns of New Grenada, and expose themselves to the rigorous climate of the paramos, or mountain-plains, generally without serious consequences to their health, whilst the inhabitants of the mountains consider a stay in the plains as a certain source of fatal diseases. Though living not far from one another, the inhabitants of these two regions do not frequently visit on account of the antipathy existing between them. When they meet, quarrels are almost inevitable, and the llaneros use the superiority in strength and activity derived from their manner of life with ferocity and cruelty. They are much feared therefore by their neighbours. Though the inhabitants of these plains have lost many of the qualities by which the character of the Spaniard is distinguished, they have preserved a certain sense of politeness and regard for other persons. This is most conspicuous when they are visited by travellers. However great their desire may be to obtain information from their guests, they forbear annoying them by questions until they have satisfied their appetites.

THE END.

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CURIOSITIES

OF

PHYSICAL GEOGRAPHY.

BY W. WITTICH.

SERIES II.

EARTHQUAKES AND VOLCANOES.

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CONTENTS.

EARTHQUAKES.

VOLCANOES.

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PHYSICAL GEOGRAPHY.

EARTHQUAKES.

1 EARTHQUAKES are undoubtedly the most fearful and at the same time the most destructive phenomena of nature. They are motions produced on the earth's solid surface by a force originating in the interior of the globe, and thence acting upward This force, which is not palpable to our senses, appears to be subject to great variations in its intensity. In most cases the commotions occasioned by it on the earth's surface are exceedingly slight The motion is scarcely felt, and passes away in the same moment The larger number of earthquakes consists of a slight trembling of the ground, which can only be perceived by attentive observation, and then only under very favourable circumstances. When they have passed away, it is impossible to discover the slightest traces of their transitory activity. But at other times they are attended with effects so terrible and destructive, that no other calamity can be compared with them. When the subterraneous force to which they owe their origin acts with a violent degree of energy, it produces such convulsions on the earth's surface, that not only are the works destroyed that men have raised to render their lives comfortable, and the buildings levelled to the ground that they have erected to protect them against the inclemency of the sea-

sons, but, in some cases, the face of the country is changed that has been subjected to their operation. It is happily the case that earthquakes attended with such fearful effects are not of frequent occurrence, they would otherwise render the countries visited by them uninhabitable for man and beast

2 In countries frequently subject to earthquakes, only those convulsions which are attended by destructive consequences are remembered by the inhabitants for any long time after The slight ones are hardly noticed, or are only recorded by some more curious observer It appears, therefore, to persons living at a great distance from such places, and receiving information of them only when producing some great calamity, that earthquakes are not frequent, and occur only at periods remote from each other. This, however, is an error Earthquakes are very frequent By an exact observer not less than fifty-seven earthquakes have been noticed within the space of forty years in the town of Palermo, in Sicily, which were attended by such smart shocks that it was possible to determine their direction There occurred, consequently, three earthquakes in every two years in Palermo. At other places they are still more frequent. In the town of Copiapò, in the northern province of Chili, one or more shocks are felt almost every day; and though they commonly pass off without causing any damage, the town has suffered by them so frequently, and so many lives have been lost by the downfall of buildings, that the inhabitants rush out of their houses as soon as the least commotion of the earth is perceived. "If it was possible,' says Alexander von Humboldt, "to obtain daily information respecting the state of the whole surface of our globe, we probably should convince ourselves that this surface is nearly always shaken at some point or other, and that it is subject to an uninterrupted reaction between the interior and the exterior."

3. Some parts of the globe's surface are much more subject to earthquakes than others, but it is hardly possible to point out any country that can be considered as entirely

exempt from their visitations? They are as frequent in mountain regions as in plains, and are experienced in both the high table-lands of the Andes and the low coasts of Belgium and the Netherlands. Where mountains and level plains are contiguous to each other, it has been observed at some places that the mountain region, and at others that the plains, were most violently convulsed. In the great earthquake of Caraccas (1812) the valley in which this town is built experienced the most violent shocks, whilst in the plains surrounding the lake of Valencia, near Caraccas, hardly any commotion was perceived. The reverse took place in Calabria (1783), where it was the plain whose face was entirely changed in a few minutes by the violence of the concussions.

It does not appear either that the geological constitution of the country has any influence upon them. Large and high rocky masses of primative formation, mountains consisting of successive layers and low alluvial plains, are equally subject to earthquakes. Thus the low alluvial plains surrounding the mouth of the Scheldt experienced many smart shocks in 1822, whilst the extensive plains drained by the Mississippi were visited by very violent concussions ten years before.

4. Many persons are apt to suppose that those countries which are situated in the vicinity of active volcanoes are more frequently subject to violent concussions than those which lie at greater distances from them. This opinion is not correct, but it is true that earthquakes are common in the neighbourhood of volcanoes. Every eruption of the mountain, and even every new flow of lava, or every ejection of ashes, is accompanied by a shock, which, however, is so slight that it can only be perceived by persons who are near the crater or on the declivities of the volcano. These slight shocks can [illegible]ly be considered as earthquakes, as they are not [illegible] in the plain at its base. But many eruptions are preceded by real earthquakes. When the inhabitants of a country surrounding an active volcano observe that the mountain has ceased to emit smoke from its crater, they consider it as a sign of an approaching earthquake,

and in many cases their fear has not proved unfounded. It may be true that earthquakes are most frequent in countries lying in the vicinity of a volcano, but few of the more disastrous convulsions of this description have occurred in such localities. The greater number have happened at considerable distances from any active volcano, and even from places which by the nature of the rocks show that they have once been the seat of volcanic activity. It is also observed that earthquakes occurring at no great distance from volcanoes are of comparatively short duration, whilst the convulsions visiting countries lying far from them are repeated almost daily for months together, and frequently several times in one day. Of such a description were the earthquakes which were experienced during more than a whole year (1812) in the plains of the Mississippi, and those which shook (1808) the Alpine valleys of Fenestrelles and Pinerolo, lying at the base of Mount Cenis. The numerous earthquakes which have occurred in the countries situated between the eastern part of the Mediterranean and the banks of the Euphrates, have almost always been distinguished by the violence of their shocks, and their frequent repetition for several months. Copiapò, which, as we have observed before, is perhaps more frequently subject to earthquakes than any other spot on the globe, is more than 250 miles distant from any active volcano. Of those earthquakes which have proved most disastrous in their effect only those of Calabria (1783), of Riobamba in the Andes (1797), and of Molise (1805), in the kingdom of Naples, have occurred within a distance of less than a hundred miles from an active volcano.

5. By far the greater number of earthquakes have been experienced in countries lying near to, or at no great distance from, the sea-shore. But it is not every part of the globe thus situated that is equally subject to them. The extensive coast-line of Africa, with the exception of the countries bordering on the Mediterranean, is rarely visited by earthquakes, and many other coasts appear also nearly free. The countries which have most frequently experienced their destructive effect, are

the countries surrounding the Mediterranean in the old continent, and, in America, those which enclose the Columbian Sea (Gulf of Mexico and Caribbean Sea), and those which lie between the Andes and the Pacific, inclusive of the mountain region itself On the islands of the Indian Archipelago, and as far north as Japan, earthquakes appear also to be very frequent, and to be attended by dreadful effects

Earthquakes are certainly much less frequent in countries forming the central portions of continents, and lying at great distances from the ocean, but even there very severe ones are sometimes experienced That part of the plain of the Mississippi River, which in 1812 experienced a great number of strong concussions, and those repeated for several months together, extends between New Madrid, on the Mississippi, to the Little Prairie (north of Cincinnati) The principal seat of the earthquake was consequently nearly equi-distant from the Gulf of Mexico and from the Atlantic, about 500 miles in either direction Earthquakes appear also to be pretty frequent at Irkutzk, in Eastern Siberia, which is at least a thousand miles from the Pacific and Arctic Seas

6 When the motion of the earth's surface caused by the earthquakes is more closely examined, it is found that it is not always of the same character, and it appears that the damage produced is less in proportion to the violence of the shock, than to the manner in which the ground is put into motion. Four kinds of movement have been noticed, and they are distinguished by the epithets *tremulous*, *undulating*, *upheaving*, and *rotatory*

The *tremulous* shocks are called in South America *Tremblores*, and are the least destructive. The surface of the earth is put into a trembling motion by them, not dissimilar to that felt in a steam-vessel running under high pressure The walls of houses, which do not rest on a solid foundation, are observed to incline slightly inward or outward, and objects which are not well supported are occasionally thrown down; but it is rarely,

any material damage is caused by these motions. These *tremblores* appear to be the most common kind of earthquake, especially in those countries of South America which lie along the Pacific, where they are felt very frequently, at least in certain seasons. Commonly they pass away in a moment, but sometimes they continue for several days. The town of Sciacca, in Sicily, was, in 1816, shaken by such a tremor for several days consecutively.

7. The *undulating* shocks are much more destructive. By their agency the surface of the earth assumes horizontal oscillations, by which the ground is alternately raised and let down again, somewhat in the manner in which the surface of the sea is agitated by a moderate breeze. They proceed in a simple and determinate direction, and Alexander von Humboldt, who paid great attention to these phenomena, and has himself experienced a great number of them, thinks that their progress may be estimated at from twenty to thirty miles per minute. They produce that motion of the ground which is called a *smart shock*, and are sometimes attended by disastrous effects. Those of a more powerful description throw down pieces of furniture, and rend asunder walls of houses not substantially built.

8. The *upheaving* shocks are far more dreaded. They are accompanied by violent perpendicular upliftings of the ground, as if repeated explosions were exerting their force upon the roof of a hollow cavern, threatening to burst open the ground, and blow into the air everything placed on it. They may also be compared to the bursting of a mine, which explodes with great force and removes the earth which it meets with in its passage. When the surface of the earth is split by them, it is hardly to be conceived what terrible destruction must be produced in a few minutes by such convulsions following each other in quick succession. There are numerous instances on record which prove the immense force with which these shocks act on the surface and on everything on it, some of them, indeed, appear almost incredible. In the great earthquake of Calabria (on the 28th of March, 1783)

the most elevated portion of the granite mountain-mass of the Aspromonte was seen to move up and down rapidly; persons were raised from the ground and thrown to a distance from the place where they were, houses were removed from their site, and carried to places higher than those on which they had been built. The famous French naturalist Dolomieu, who examined the country attentively a short time after that frightful catastrophe, states that the foundation of many buildings had been removed from beneath the ground with such violence, that the stones had been broken to pieces and scattered about, and the hard cement which united them had been crushed into dust. After the great earthquake of Riobamba (1797), on the table-land of Quito, the corpses of several of the inhabitants of the town were found on the top of a hill, separated from the place by a river, and several hundred feet higher than the site of the town. These persons had been hurled to the top of the hill by the violent upheavings of the ground.

9. It would seem that the upheaving shock is almost always accompanied by an undulating motion. Humboldt, at least, states that in his opinion these two kinds of motion were combined in all the stronger earthquakes he has experienced. Dolomieu makes the same observation respecting the earthquake of Calabria. In all the accounts he collected respecting the first great shock (5th of February) the inhabitants concurred in stating, that the motions had been horizontal and perpendicular at the same time, and he thinks that a pretty just idea of their united efforts may be formed by making small cubes of damp clay mixed with sand, and by placing them near each other on a table, and in that situation putting them into motion by a violent concussion from below, whilst at the same time the table is moved horizontally from one side to the other.

10. The *rotatory* shocks are certainly the most destructive, but are those also which occur most rarely. They have only been observed in the most calamitous earthquakes, and not in all of them. The whirling motion with which they affect the surface appears to be the

result of a combination of the undulating and upheaving motions, or perhaps of two or three undulating motions crossing one another at right angles or obliquely The surface of the earth is put into a movement by them, resembling that of the sea when agitated by irregular waves crossing and repulsing each other in different directions. Many naturalists have expressed a doubt of the occurrence of this kind of shock, but there are many well-established facts on record, which do not admit of an explanation but by admitting that the changes of position observed in walls and other objects have been effected by shocks of such a description In the earthquake of Catania in Sicily (1818) the general motion was clearly directed from south-east to north-west, but many statues had been turned round, and a large piece of rock had its former position from south to north changed to that of east to west Several instances of this kind were observed after the great earthquake of Valparaiso, in Chili (1822), when that town was levelled to the ground The large church, La Merced, presented the most remarkable ruin The tower was built of bricks and mortar, and its walls up to the belfry were six feet thick They were shivered into blocks, and thrown to the ground On each side of the church were a number of square buttresses of good solid brick-work, six feet square Those on the western side were all thrown down, as were all but two on the eastern side, these two were twisted from the wall in a north-easterly direction, each presenting an angle to the wall The twisting to the north-east was noticed in several other places. In a village thirty miles north of Valparaiso, the largest and heaviest pieces of furniture were turned in the same direction In the last great earthquake of Concepcion, in Chili (1835) rotatory shocks must also have occurred, as it was found that an angular stone pinnacle had been turned half-round without being thrown down or leaving its base Humboldt mentions that rows of trees running in a straight line were, after an earthquake, found to present a very perceptible curve in their line

*11. There are recorded some other well-ascertained

changes produced by earthquakes, which cannot be satisfactorily explained but by supposing that the motion produced by the shock must have been of a still more complicated nature. In some instances it has been found that large pieces of ground had exchanged their respective situations. This was the case at several places in Calabria, after the first great shock had passed by. A plantation of mulberry-trees had been carried into the middle of a corn-field and left standing there, and a piece of ground sown with lupines had been forced into a vineyard. For several years after the earthquake, law-suits were brought in the courts of Naples to decide the claims which had originated in the confusion of territorial possessions by the effects of that terrible catastrophe. Facts of such a description are not recorded as having resulted from other earthquakes, except from that of Riobamba (1797), where also several law-suits were brought in the courts respecting the possession of pieces of ground, which, in a similar manner, had exchanged their positions. It is difficult to conceive by what kind of motion the earthquakes acquire this translatory power. But Alexander von Humboldt has recorded a still more extraordinary fact. When he was surveying the ruins of the destroyed town of Riobamba for the purpose of making a map, he was shown the place where the whole furniture of one house was found buried beneath the ruins of another. The upper layer of the soil, formed of matter not possessing a great degree of coherency, had moved like water in running streams, and we are compelled to suppose that these streams flowed first downwards, then proceeded horizontally, and at last rose upwards. The motion in the shocks which were experienced in Jamaica (7th of July, 1692) must have been not less complicated. According to the account of an eye-witness, the whole surface of the ground had assumed the appearance of running water. The sea and the land appeared to rush on one another, and to mingle in the wildest confusion. Some persons who, at the beginning of the calamity, had escaped into the streets, and to the squares of the town,

to avoid the danger of being crushed under the ruins of the falling houses, were so violently tossed from one side to the other, that many of them received severe contusions, and some were maimed. Others were lifted up, hurled through the air, and thrown down at a distance from the place where they had been standing. A few who were in town were carried away to the harbour, which was rather distant, and there thrown into the sea, by which accident however their lives were saved.

12. Having given an idea of the nature of the motions attending earthquakes, a description of the effects they produce on the works and life of man should be added. This, perhaps, cannot be done more completely than by giving an account of two of those earthquakes which were distinguished by their destructive effects, and of which a pretty complete picture may be formed by collecting the facts recorded by eye-witnesses in the reports published by them. These are the earthquakes of Lisbon, in Portugal, and that of Carâccas, in Venezuela.

The earthquake of Lisbon happened on the 1st of November, 1755. The day broke with a serene sky and a fine breeze from the east. About nine o'clock in the morning the sun began to grow dim, and about half an hour later a rumbling noise was heard, which proceeded from under ground, and resembled that made by heavy carts passing over a distant ground covered with pebbles. This subterraneous noise increased gradually, but quickly, so that after a few seconds it resembled the firing of cannons of heavy calibre. In this moment the first shock was felt. Before its violent concussions the foundations of many large buildings, especially the palace of the Inquisition and several churches, gave way, and the whole of these edifices were levelled to the ground. After a short pause, perhaps of not more than a minute's duration, three other shocks followed in quick succession, by which nearly all the other larger buildings, palaces, churches, convents, public offices, and houses were thrown down. All these shocks occurred in a space of less than five minutes. At the time the first shock was felt in the city, some persons were in a boat on the Tagus river,

about three miles distant from the capital. They were astonished at hearing the boat making a noise, as if it were running a-ground, as they knew it was in deep water. In the same moment they observed on both banks of the river that the buildings were tumbling down. About four minutes later a similar noise was heard under the boats, and other buildings were seen falling to the ground. During this time a strange commotion was observed in the water of the river. It appears that at some places the bottom of the river was raised to the level of the water. Many vessels were lying in the harbour opposite the town. Some of them were torn from their anchors and dashed against each other with great violence; in others, the sailors did not know whether their vessels were afloat or aground.

The minds of the inhabitants had not yet had time to recover from the terror caused by this terrible and quite unexpected catastrophe, when they were again plunged into dismay by a phenomenon of a different description, but hardly less terrible and destructive. About half an hour after the most severe shocks had ceased, the sea suddenly rushed with incredible velocity into the river. Although the water had been ebbing for two hours, and the wind blew fresh from the east, the sea at the mouth of the Tagus rose instantaneously about forty feet above high-water-mark, according to the statement of some eye-witnesses who observed it at Colares and other places between the Bay of Lisbon and the sea. It would certainly have laid more than half the town under water, and completed the work of destruction, had not the large bay, which the river forms opposite the capital of Portugal, permitted this enormous volume of water to spread itself over a surface of many square miles. But even this favourable circumstance did not entirely exempt the city from the effects of an inundation. The sea entered the lower streets, and a large stone-built quay, which had been probably detached from its foundations by the earthquake, and on which about three thousand people had taken refuge, was suddenly hurled bottom upward, and every soul was lost. As quickly as the water had filled the

river, so quickly did it retreat to the sea The high wave, however, returned three or four times before the water attained its usual level, but every time with a diminished force and a less volume of water

It is stated that, by the effects of the earthquake and of the inundation, not less than sixty thousand persons perished The larger number, it appears, were crushed by the ruins of the falling churches For as it was a holiday, a great number of persons were at their devotions in the churches and convents, which, being very substantial edifices built of stone, suffered much more than the houses of private persons, and were reduced to heaps of ruins by the first shock Towards evening a smart shock was felt, it was strong enough to split the walls of several houses which had still kept their position The rents caused by this shock in the walls of these houses were more than half a foot wide, but as soon as the shock had passed away they closed again, and so firmly that it was impossible to find a trace of them

In addition to the horrors occasioned by the shocks of the earthquake and the inroads of the sea, the devoted inhabitants were exposed to the ravages of fire Mr Davy, an English merchant residing in Lisbon, who escaped, and published an account of the calamity, says, "As soon as it grew dark, another scene presented itself little less shocking than those already described—the whole city appeared in a blaze, which was so bright that I could easily see to read by it It may be said without exaggeration, it was on fire at least in a hundred different places at once, and thus continued burning for six days together, without intermission, or the least attempt being made to stop its progress

"It went on consuming everything the earthquake had spared, and the people were so dejected and terrified, that few or none had courage enough to venture down to save any part of their substance, every one had his eyes turned towards the flames, and stood looking on with silent grief, which was only interrupted by the cries and shrieks of women and children calling on the saints and angels for succour, whenever the earth began to trem-

ble, which was so often this night, and indeed I may say ever since, that the tremors, more or less, did not cease for a quarter of an hour together I could never learn that this terrible fire was owing to any subterraneous eruption, as some reported

* * * *

The 1st of November being All Saints Day, a high festival among the Portuguese, every altar in every church and chapel (some of which have more than twenty) was illuminated with a number of wax tapers and lamps, as customary, these setting fire to the curtains and timber-work that fell with the shock, the conflagration soon spread to the neighbouring houses, and being there joined with the fires in the kitchen chimneys increased to such a degree, that it might easily have destroyed the whole city, though no other cause had concurred, especially as it met with no interruption "

He also gives a vivid picture of the destruction occasioned, and of its effects on the population

" The nobility, gentry, and clergy, who were assisting at divine service when the earthquake began, fled away with the utmost precipitation, every one where his fears carried him, leaving the splendid apparatus of the numerous altars to the mercy of the first comer, but this did not so much affect me as the distress of the poor animals, who seemed sensible of their hard fate, some few were killed, others wounded, but the greater part, which had received no hurt, were left there to starve.

" From the square, the way led to my friend's lodgings, through a long, steep, and narrow street, the new scenes of horror I met with here exceed all description; nothing could be heard but sighs and groans I did not meet with a soul in the passage who was not bewailing the death of his nearest relations and dearest friends, or the loss of all his substance, I could hardly take a single step without treading on the dead or the dying, in some places lay coaches, with their masters, horses, and riders, *almost* crushed in pieces; here, mothers with their infants in their arms, there ladies richly dressed, priests,

friars, gentlemen, merchants, either in the same condition, or just expiring; some had their backs or thighs broken, others vast stones on their breasts: some lay almost buried in the rubbish, and, crying out in vain to the passengers for succour, were left to perish with the rest."

All the country lying round Lisbon suffered more or less from the effects of this earthquake. Many of the large mountains were shaken to their very foundation, and some had their summits rent. Large pieces of rock were detached from them, and precipitated into the valleys, where they caused considerable damage to the plantations and vineyards. At Colares, it was observed that a very thick smoke issued from a rock not very distant from the place. The quantity of smoke which arose was always in proportion to the loudness of the subterraneous rumblings. The smoke continued to issue for some time after the earthquake had subsided. When the place was afterwards closely inspected, no traces of any rent were discovered in the rock.

Though the destructive effects of these shocks were most severely felt at Lisbon, which appears to have been the centre of the earthquake, the whole coast of Portugal was afflicted by them. At Oporto the shocks were nearly as violent as at Lisbon. At about forty minutes past nine a frightful hollow noise was heard similar to distant thunder. By some it was compared to a number of carts running over an uneven stone pavement. In the same moment the first shock was felt, which lasted about five minutes, and shook the whole town to its very foundation. The damage, however, was comparatively small. Only a few houses suffered material injury, but the walls of several churches were split. In many places it was observed that the ground of the streets alternately rose and subsided. The waters of the river were in great commotion. They rose and fell five or six feet within each two minutes, and this movement continued for about four hours. At several places the surface of the water appeared to divide to give vent to large volumes of gas or of steam, and at the same time the sea at the

mouth of the river appeared to be in a state of agitation resembling that of vehement ebullition. It was supposed that in this part, too, gas must have escaped from the bottom of the sea

South of Lisbon, the destruction was much greater. The harbour of Setubal was changed considerably by the shocks of the earthquake, and almost entirely destroyed by the inundation of the sea The town of Ayamonte, near the mouth of the river Guadiana, suffered still more. The shocks continued for fourteen or fifteen minutes, and injured nearly all the houses At the same time the surface of the earth opened at several places, and large volumes of water rushed out from those chasms The sea rose three times, and all the streets were inundated

Cadiz, too, had its share of the effects of this earthquake. The rock on which the town is built, and which is joined to the continent by a narrow and low isthmus, was shaken nearly at the same time that Lisbon experienced the first shock The oscillations of the ground continued for about three minutes and a half, and put the population into great terror, but it was afterwards found that the damage done by these convulsions was but trifling Hardly had the first impression of fear passed away, when, about ten minutes past eleven o'clock, another phenomenon of more terrific appearance was seen approaching, and threatening the whole town with destruction At a distance of about ten miles west of the place, the sea was suddenly rising to a height of about sixty feet above its common level, and thus a watery wall was formed which advanced with great velocity towards the town. At this sight the whole population was thrown into the utmost consternation The sentinels placed on the fortifications erected towards the open sea, observing the advance of the huge wave, abandoned their posts, and the people, informed of the impending danger, rushed towards the gate which leads to the above-mentioned isthmus It was a very happy circumstance that the governor of the place was a man of sense and resolution. He directly ordered the gates of the place to be closed, so that but few succeeded in getting on the isthmus.

Meanwhile the wave had reached the shore, and dashed against the rocks with a terrible crash. But its force was greatly broken by the cliffs which lie in front of the rock on which the town is built. It was, however, still strong enough to demolish the walls and fortifications on that side, and to remove some heavy pieces of artillery to a distance of more than a hundred feet. When the wave, however, reached the town its force had so abated, that it inundated only the lower streets, and caused very little damage. Still the loss of life was considerable. For, having passed the town, it rushed with great force over the low isthmus lying at the back of it, and all those who had retreated to it, hoping thus to provide for their safety, were drowned. The sea retreated with as much velocity as it had advanced, and carried off a large volume of the waters filling the Bay of Cadiz, for it was observed that for a few minutes the shallower parts of the bay were laid dry. Then the large wave returned. This alternate advancing and retiring of the sea took place four or five times, but at every repetition the volume of water was less.

At Gibraltar the earthquake lasted for about two minutes. The oscillations of the surface were quick and strongly undulating, so that some of the cannons standing on the walls of the place were raised at one place, whilst others were sinking lower. Many of the inhabitants felt their heads turning, others were attacked by sickness, some fell to the ground, whilst others were stunned. Many who were walking or riding on horseback did not feel any motion, but they were affected by a feeling of illness. At every quarter of an hour the sea swelled about six feet, and then retired so as to leave aground all the boats and smaller vessels which were at anchor near the shore. Those tracts left dry by the sea were strewed with dead fish. The alternate changes of high and low water continued till six o'clock the following morning, but after two o'clock in the afternoon they began to diminish in height, and went on gradually decreasing until they ceased.

13. The earthquake of Caraccas, the capital of Venezuela, in South America, occurred on the 26th of March, 1812 This city is built in a valley about five miles wide, on uneven ground. Its principal square is 2880 feet above the sea-level On the southern side of the place runs a river of moderate size called Guayra Between the town and the sea, from which it is about twenty miles distant, are mountain-masses which occupy nearly the whole space, and rise to upwards of five thousand feet above the sea. One of the summits, called the Silla of Caraccas, rises more than 8000 feet.

The 26th of March was a remarkably hot day. The air was calm and the sky cloudless. It was Holy Thursday, and a great part of the population was assembled in the churches There was nothing observed which presaged the calamities that were impending. At seven minutes after four in the afternoon the first shock was felt It was sufficiently powerful to ring the bells of the churches, and lasted about five or six seconds. During its action the ground was in a continued undulating motion, and seemed to heave up like a boiling liquid It was thought the danger had passed, when a tremendous subterraneous noise was heard, resembling the rolling of thunder, but louder and of longer duration than even that which is heard between the tropics in the season of storms This noise was immediately followed by a perpendicular shock which lasted three or four seconds, closely succeeded by an undulating movement somewhat longer The motion of these undulating shocks was complicated, some running north and south, and others east and west Nothing was able to resist the movement of the shocks raising the ground upwards from the bottom, and of the undulations which crossed one another In a few instants the town was almost levelled to the ground. A large portion of the population, between nine and ten thousand according to the most credible statements, was buried under the ruins of the houses and churches. The procession, which is usually made on that day in all Catholic countries, had not yet set out, but the crowds assembled

in the churches were so numerous, that between three and four thousand persons are said to have been crushed by the downfall of their vaulted roofs The explosion was strongest along the northern skirts of the town, the quarter which is situated nearest the mountains of Avila and the Silla. The churches of La Trinidad and of Alta Gracia, which were more than a hundred and fifty feet high, and the naves of which were supported by pillars of twelve or fifteen feet diameter, left a mass of ruins scarcely exceeding five or six feet in elevation It was evident that the site of these buildings had sunk, and this sinking had been so considerable that hardly any vestiges of the pillars or columns could afterwards be discovered. The large barracks, very substantial buildings, which were situated to the north of La Trinidad, disappeared almost entirely A regiment of troops of the line that was assembled there under arms, to be ready to join the procession, was, with the exception of a few men, buried under the ruins of that great edifice. Nine-tenths of the town were levelled to the ground The walls of the houses which were not thrown down were cracked in such a manner that nobody was inclined to run the risk of inhabiting them The effects of the shocks were somewhat less destructive in the western and southern quarters of the city, where the cathedral, supported by enormous buttresses, remained standing. The duration of the earthquake, that is to say, the time in which both the undulating and upheaving shocks were perceptible, was by some estimated at one minute and twelve seconds; by others at only fifty seconds

The night following Holy Thursday presented a most afflicting scene of desolation and sorrow The thick cloud of dust which, rising from the ruins during the day, had hovered above the ruined city and darkened the sky, now settled on the ground. No shock was felt, and never was a night more calm and more serene. The moon, nearly full, illumined the rounded domes of the Silla, and the aspect of the sky formed a terrific contrast to that of the earth, covered with corpses and heaped with ruins. The mind of the looker-on was afflicted by

the most heart-rending scenes. Mothers were seen carrying in their arms the children whom they hoped to recal to life Distressed families were climbing over the ruins to find out a brother, a husband, or a friend, of whose fate they were ignorant, and whom they believed to be lost in the crowd The people, oppressed by the weight of the calamity, passed silently along the street, which could only be traced by the long lines of ruins Those who were buried under the ruins, and were unable to extricate themselves, implored the assistance of the passengers by their cries, and a number amounting to nearly two thousand were afterwards dug out. Never was pity displayed in a more affecting manner, never had it been seen more ingenious in its activity, than in the strenuous attempts made for the purpose of saving the miserable victims whose groans reached the ear. Implements for digging and clearing away the stones and rubbish were not at hand they had been buried under the ruins. The people therefore were compelled to use their bare hands to disinter the living The wounded, as well as the sick who had escaped from the hospitals, were carried to the borders of the river Guayra, but the only shelter they found was the foliage of the trees Beds, linen to dress the wounds, instruments of surgery, medicines, objects of the most urgent necessity, were many feet deep under the ruins Everything, even the coarsest provisions, were wanting during the first few days Water also became scarce in the interior of the city. The repeated concussions had rent the pipes of the fountains, the falling-in of the earth had choked up the springs that supplied them, and to get water people were compelled to go to the river, which happily was considerably swollen But it was impossible to convey the water to any distance, as vessels for that purpose were wanting.

People applied themselves to the exercise of those religious duties, which in their opinion were most fitted to appease the wrath of Heaven. Many assembled, and passed through the streets in processions singing funeral hymns; others, thrown into a state of distraction by

these calamities, confessed their sins aloud in the streets; numerous marriages were contracted between persons who for many years had neglected to sanction their union by the sacerdotal benediction, children found parents by whom they had not been acknowledged up to that time, restitutions were promised by persons who had never been accused of fraud or theft, families, which for many years had been estranged from one another by enmity and hatred, were drawn together by the tie of common suffering Though these feelings, by which the passions of some were soothed, and the hearts of others were opened to pity and humanity, were prevalent, there were not wanting other persons whose indurated minds were rendered more inhuman and cruel.

The night passed in quietness For fifteen or eighteen hours after the great catastrophe the ground remained tranquil, but on the 27th of March the commotions recommenced They were attended by a very loud and long continued subterraneous noise The inhabitants of the town abandoned the place, and dispersed themselves over the surrounding country but finding that all the villages and hamlets in the valley had suffered as much as the city, and could not supply them with the first necessaries of life, they repaired to the valley of Aragna, more than thirty miles distant from the capital. Meanwhile the shocks continued to shake the city, no less than fifteen oscillations being felt in one day On the 5th of April there was a shock, almost as violent as that by which the capital had been overthrown. During several hours the ground was in a state of perpetual undulation Large masses of earth were shaken off from the declivities of the mountains, and enormous rocks were detached from the Silla of Caraccas. The commotions ceased only on the 30th of April.

The mountainous country, lying to the west of Caraccas, also experienced the dreadful and destructive effects of the earthquake. It appears that the motion proceeded in a line running east-north-east, and west-south-west from the harbour of La Guayra and Caraccas

to the lofty mountains of Nequitao and Merida. Along this tract it acted with great violence, and many towns were entirely destroyed, especially La Guayra and San Felipe. But in the valley of Aragna, which lies between Caraccas and San Felipe, the convulsions were very weak and did not cause any material damage. Many places along the coast, as far as the lake of Maracaibo, suffered greatly, but at Coro no commotion was felt, though the town is situate upon the coast, and between other towns which suffered from the earthquake The waves of the agitated ground extended westward as far as the valley of the Rio de la Magdalena, and smart shocks occurred at Sta Marta, Bogota, and Honda

14 There is no event which makes so deep and lasting an impression on the mind as an earthquake, nor does any other phenomenon of nature affect it to an equal degree, hence those who have not experienced an earthquake are unable to judge of the state of mind into which people are thrown by it Confusion, distraction, and horror, carried to the highest pitch, do not convey an adequate idea of what is passing in their breasts The principal cause of this extraordinary state of mind is doubtless founded on the circumstance, that an earthquake unsettles our whole system of thinking and reasoning, by withdrawing the foundation on which it rests From our earliest years we have been accustomed to consider the soil under our feet as firm and immoveable We have unconsciously connected this idea with all our conceptions, feelings, and actions; and it thus becomes the base of all our plans, intentions, and wishes Our whole life, with all its events and operations, rest on this idea as on an immutable foundation. An earthquake, by turning it into a delusion, overthrows our whole system of thinking and acting. We are no longer able to collect our thoughts so as to form an idea, we cannot conceive any plan, nor take any resolution. The faculty of thinking is, as it were, paralysed, and our mind thrown into the utmost confusion. The difference between a strong and a weak mind disappears. We are no longer guided by principles or reason, we follow only

the involuntary impulses of instinct, or, in the most favourable circumstances, we are influenced by some feelings arising from some previous ideas which fortunately have been indelibly impressed on our mind.

A gentleman of Copiapó expressed himself on this point, to Captain B Hall, as follows:—"Although I am not a man to cry out and play the fool on such occasions, yet I do fairly own that these earthquakes are very awful, and indeed must be felt to be understood in their true extent Before we hear the sound, or, at least, are fully conscious of hearing it, we are made sensible, I do not know how, that something uncommon is going to happen, everything seems to change colour, our thoughts are chained immoveably down, the whole world appears to be in disorder, all nature looks different to what it was wont to do, and we feel quite subdued and overwhelmed by some invisible power beyond human control or comprehension Then comes the terrible sound distinctly heard, and immediately, the solid earth is all in motion, waving to and fro like the surface of the sea. Depend upon it, a severe earthquake is enough to shake the firmest mind. Custom enables us to restrain the expression of alarm, but no custom can teach any one to witness such earthquakes without the deepest emotion of terror"

The utter confusion and uncertainty of the mind, which must arise from the complete overthrow of our common system of thinking and acting, is converted into terror by those circumstances which always attend earthquakes, and which powerfully affect our senses All the attempts at keeping one's footing, whilst the earth is continually and violently heaving up and down with a quickness of which no one can form an idea but those who have witnessed it, prove useless and embarrassing to the highest degree The tottering buildings, the cracking of the timbers of the roofs, and the falling of the tiles, together with the loud rumbling noise immediately under the spot on which we are standing, completely distract the senses. Men would abandon themselves entirely to the overwhelming operations of

nature, if they had not strongly impressed on their minds the sad experience, that most persons have perished in earthquakes by having been crushed under the ruins of the buildings. This impression acts like an instinct on them. They rush out of the houses, but too frequently not to find safety out of doors. They soon find that they cannot keep their footing without support; they cling to one another, to trees, or to posts. Some throw themselves to the ground, but the motion of the earth is so violent, that they are compelled to stretch out their arms to prevent themselves from being tossed over. Here and there the earth opens, and deep chasms present themselves to their eyes. There are no means of escaping from these threatening dangers. Persons may retire in safety out of the reach of the eruption of a volcano, they may easily avoid the current of burning lava advancing towards them, and even when suddenly overtaken by an inundation, they soon perceive in what direction they have to fly to avoid being overwhelmed by the rushing volume of water; but during an earthquake every one is impressed with the conviction, that wherever he goes he places himself over the focus of destruction.

It may easily be conceived that all those who have experienced a severe earthquake are terrified at any uncommon appearance. The slightest undulation of the ground or any unusual noise rouses their attention, and they immediately rush out of their houses. But habit influences the mind in this case too. When for a number of years a place has only been visited by moderate shocks, not attended by destructive effects, the inhabitants, by degrees, get rid of every kind of fear. "In Lima," says Humboldt, "this habit, united to the generally prevailing opinion, that destructive earthquakes do not occur more than two or three times in a century, has rendered the inhabitants so indifferent to slight shocks, that they do not pay more attention to them, than we do to a hail-storm."

16 When, after a very severe earthquake, the sufferers' minds become sufficiently collected to contemplate the

effects produced, they are astonished at the extent of destruction, and they feel another kind of terror, when they consider in what a short time it has been brought about. The most destructive shocks are of very short duration, and seem quite out of proportion to the effects they have produced. In some cases it even appears that the amount of destruction and the time of duration are to each other in an inverse proportion: the shorter the shock, the greater the devastation. The most destructive shocks, by which thousands of persons lost their lives, flourishing towns were converted into heaps of ruins and whole provinces convulsed, lasted, in many cases, as it were, only an instant. Thus, as we observed, in giving an account of the earthquake of Caraccas, that place was entirely levelled to the ground by three shocks, each of which did not continue for more than three or four seconds, and all of them occurred within a space of less than a minute. The shock which, on the 5th of February (1783), converted a large portion of Calabria into one general ruin, did not, according to the statement of the inhabitants, exceed two minutes in duration; and in 1692 the face of the island of Jamaica was, in three minutes, so changed, that hardly a tract could be found which had preserved the appearance it had borne previous to the earthquake. We may even suppose that the time of duration in the two last-mentioned cases has been probably overrated. For as there were no signs indicating the approach of the earthquake, the precise moment of its beginning cannot easily be determined exactly; and we may assume that people, placed suddenly in such a state of terror, and longing for the moment of its cessation, have estimated the time of duration much longer than it really was. When this is considered, we may well agree with Humboldt when he says, that there is no force known to exist, not even the murderous inventions of our own race contrived for each other's extirpation, by which in the short period of a few seconds or minutes such a number of persons can be killed, as by an earthquake. In Sicily, in 1692, not less than 60,000 perished;

in Riobamba and its neighbourhood, in 1797, from 30,000 to 40,000, in Calabria, in 1783, perhaps 100,000, and in Asia Minor and in Syria, in the time of Tiberius and Justinian, perhaps not less than 250,000

16 It happens sometimes, though not frequently, that an earthquake which is attended by smart shocks affects only a comparatively small tract of country Thus a portion of the mountains of Madonia, in Sicily, not extending over a great number of square miles, experienced, in 1832, during several months, a considerable number of smart shocks, whilst all the surrounding places, though frequently subject to earthquakes, did not evince the least commotion of the ground In general, however, countries of considerable extent are affected by them In many cases it appears that the shock is felt at the same moment in places distant from each other The shocks which destroyed Lisbon occurred at ten minutes to ten o'clock in the forenoon, and the town of Madrid suffered much damage by shocks which occurred at seventeen minutes past ten which is the same moment of time when the geographical longitude of the two places is computed In most cases, however, it is found that the shocks are felt somewhat earlier in one place than in those which are distant from it, and that the interval between the time in which they are effected is in proportion to the distance It is remarkable that, as far as our observations go, the shocks are always most severe and most destructive at that place where they are first felt Such a place is therefore reasonably considered as the centre of the earthquake From this centre the earthquake proceeds either in a determinate direction towards certain points of the compass, or it spreads round the centre over all the adjacent countries In the first case it is called a linear earthquake, and in the second a central one

17 The linear direction of earthquakes is most common in those countries which are traversed by mountain-ranges It is usually found that in such countries the tracts shaken by the commotion form a band parallel to

the ranges, and at no great distance from their bases This has even been observed in the earthquakes which have visited our island. The smartest shocks which have been felt in our country (those of 1750, 1777, 1792, and 1795), proceeded slowly from south-west to north-east, but kept distinctly within a narrow band, extending nearly parallel to the continuation of the highest ground of the island This linear direction has been much more distinctly observed in the countries lying between the Andes and the Pacific, more especially in the earthquakes of Lima (1746), of Copiapo (1819), of Valparaiso (1822), and of Concepcion (1835) The earthquakes proceeded from the centre to the south and to the north, and the shocks were felt sooner or later, according to the distance of the places from the centre Humboldt thinks that in general the earthquake progresses from twenty to thirty miles in each minute According to the statement of this scientific traveller, there occur, in these countries, certain tracts of land or places which do not experience the shocks, though the countries contiguous to them on the north and south are convulsed to a considerable degree, and it is remarkable that none of the numerous earthquakes have ever visited such places To describe this curious exemption from earthquakes, the creoles of the country say that *they form a bridge*, expressing by this phrase their opinion that the shocks pass under these places at too great a depth to affect them, whilst beneath the adjacent tracts they approach nearer the surface of the earth

18 In the central earthquakes the shocks are not propagated in a certain determinate direction but spread on all sides, like rays issuing from a common centre The progress of these shocks may be compared to the ring-like waves produced on the surface of still water by a pebble being thrown into it, such waves grow wider and fainter in proportion to the distance from the spot on which the stone fell. For it is generally observed that the farther the wave of the earthquake, if such a term may be used, advances from the centre, the less

the shock is felt The earthquake of Lisbon was a central one, and its waves extended over a very large section of the globe The centre was unhappily under or near that capital, for it is stated by persons who were at Colares, near the mouth of the Tagus river, that the severe shocks which were experienced at that place were felt as if coming from the side on which Lisbon lies, though at that moment nothing was known of the calamity which had overtaken the capital At the island of Madeira the earthquake was felt somewhat later, and the shocks appeared to proceed from the north People inhabiting the Antilles and the coasts of the Columbian Sea were of opinion that they came from north-east When the wave, originating at Lisbon, reached our island it had already greatly expended its force Smart shocks, however, were still felt along the southern coast, and at Cork, in Ireland, but in proceeding farther north its force gradually died away

In the earthquake which occurred in Belgium, in February, 1828, it was also evident that the shocks had spread over the country like rays round a centre The first and smartest shock was felt in a tract of land having the form of an ellipsoid extending from east to west. It comprehended that part of the country which lies between Brussels, Waterloo, Liege, and Maestricht From this centre the waves advanced to the places lying higher up on the banks of the Meuse and of the Rhine. On the east they were perceptible as far as Soest, in Westphalia and on the west they reached the towns of Flushing and Middelburg on the Island of Walchern

19 In by far the greater number of earthquakes, of which we have accounts to be relied on, the centre of the catastrophe was at a certain point But in earthquakes which are protracted over several weeks or months, it appears that the centre sometimes changes its place This appears to have been evidently the case with the earthquakes which, in December, 1811, were first felt on the banks of the Lower Mississippi, and afterwards proceeded slowly farther north, increasing at the same time in force, until, in February, 1812, they

reached the country between the Lower Ohio and the middle course of the Mississippi, where their rather severe shocks continued for many months In the earthquakes which in February and March, 1783, afflicted the province of Calabria, three centres have been distinctly pointed out, and it appears that the shocks at one time proceeded in a linear direction, and at another spread round the centre. These earthquakes affected, indeed, only a comparatively small part of the country, but if the intensity of the shocks and the amount of damage are considered, they were much more severe than most of those of which a detailed account has been recorded The earthquake which, in 1692, convulsed the island of Jamaica, appears to have been the only one attended with nearly the same destruction Considering the great changes the earthquakes of Calabria produced on the face of the country, and the peculiar phenomena above mentioned, it appears not to be out of place to give a detailed account of them No eye-witness has given a description of what he observed or experienced, but as shortly after the cessation of the motions several scientific men of great reputation visited the country, and were at great pains to collect every kind of information concerning these horrible phenomena, and as, on the whole, their statements agree with one another, we may rely on the information contained in their publications

The destructive effects of the earthquakes of Calabria were severely felt in the most southern portion of the Italian peninsula, and in the north-eastern part of Sicily That portion of the peninsula which suffered most is known by the name of Calabria Ultra It is a tongue of land, extending south-south-west and north-north-east, about sixty miles in length, with a mean breadth of somewhat more than twenty miles. The Straits of Messina separate it from the island of Sicily. With the broader portion of the peninsula of Italy it is connected by an isthmus, which on the west is washed by the gulf of Sta Euphemia, and on the east by that of Squillace. The surface of this isthmus rises only to a

moderate elevation above the sea-level, so that the mountain-masses lying north and south of it are not connected, but constitute separate systems. The tongue of land lying south of this isthmus exhibits some singularities in the formation of its surface. At each of its extremities are mountain-masses, which extend over the whole width of the country from sea to sea The northern mass rises in the middle to about 4000 feet above the sea-level, and sends off several offsets, which on the east terminate on the sea with Cape Stilo, and on the west fill up with hills the projecting tract of land between Cape Zambrone and Cape Vaticano. The southern mountain, known by the name of Mount Aspromonte, rises to more than 5000 feet above the sea, and constitutes a more compact mass, its sides being only furrowed by short and narrow valleys, separated from each other by high ridges. These two masses are connected by a ridge of little width, which runs nearly in the middle of the tongue of land, but somewhat nearer the eastern than the western shores. Low offsets from this ridge render the country east of it hilly, but that which lies on the west of the ridge is a plain, whose surface is covered with a very thick layer of clay mixed with sand and full of marine shells In this plain the numerous small rivers which originate in the ridge have scooped out their beds many feet below the general surface The face of this plain was almost entirely changed by the first two earthquakes, whilst it was little affected by the third. The first two earthquakes occurred on the 5th and 7th of February The centre of the first and most destructive shock was at Oppido, near the southern extremity of the plain, and that of the second at Soriano, near the northern extremity. These two places are about twenty miles distant from each other. The shocks began with strong undulations, which were soon changed into rotatory motions The concussions were so violent that the heads of the largest trees are stated to have almost touched the ground from side to side. No kind of building was able to resist the effects of these violent

motions, they were all thrown into heaps of ruins. The surface of the country was rent by deep chasms running in different directions, many of which remained open for a long time afterwards Some, when visited three months after the earthquake, were found to be still more than a foot in width, but they had been much wider during the earthquake Others closed as soon as the shocks had passed away in one of them an ox and a hundred goats were swallowed up By these rents such pieces of ground as were contiguous to the deep ravines in which the rivers flow, were detached, and precipitated down and in this way the ravines were partly filled up and the courses of the rivers stopped or altered Many springs of water appeared in places which had been dry before, and others totally disappeared Pieces of ground of several acres in extent with the plantations of olive-trees or mulberry-trees on them, were carried to a distance of a quarter of a mile and upwards from their original site, other pieces of similar extent, with timber trees or crops of corn, had sunk eight or ten feet, and others had been raised as many In two or three places it was found that fields planted with different kinds of trees, or sown with different kinds of corn, had exchanged their situations Where the soil contained a considerable portion of sand, numerous holes were found, which were some feet in depth, and had the form of an inverted cone, during the shocks hot water had issued from them The ruin of the towns and villages was as complete as the wildest imagination could fancy The complicated shocks had thrown the houses upon each other, so that they formed heaps of ruins, in which it was impossible to distinguish streets or buildings.

From the centres above mentioned the waves of the earthquake extended all around On the east they passed through the ridge which lies on that side of the plain, but it appears that the mountain-masses had broken their force, as the damage done by these shocks along the eastern coast of Calabria was not considerable. In a northern direction the shocks were felt on the isthmus between the gulfs of Sta. Euphemia and of

Squillace, but caused no great injury On the west the oscillations extended to the Lipari Islands, whose inhabitants assured Dolomieu that there was no doubt that the shocks on the 5th of February had proceeded from the side on which the town of Oppido is situated. Severe shocks were also felt in Reggio and Messina, two towns built on the Straits of Messina Reggio suffered severely, but much less than Messina, probably because the mountain-masses of the Aspromonte had broken the violence of the concussions, a great part of Messina was destroyed The inhabitants of this rich mercantile town stated that the earthquake had proceeded along the coast of Calabria to the north-eastern point of Sicily, Cape Peloro, and thence along the shores of the island to the town of Messina When the rumbling noise was heard at this place, which usually attends earthquakes, the opposite coast of Calabria was seen enveloped in dust, and the houses built there were tumbling down one after the other, until the oscillations of the ground reached the Palazzata, a lofty series of buildings enclosing the port of Messina in the shape of a crescent, and partly converted them into a heap of ruins, partly precipitated them into the sea.

The third great earthquake in Calabria occurred on the 28th of February, seven weeks after the last great shock in the plain The centre of this earthquake was removed much farther to the north. It was near the town of Gritalco, situated more than twenty miles distant from Soriano, and on the very isthmus between the gulfs of Sta Euphemia and Squillace It is very remarkable that the plain which had so violently been convulsed on the 5th and 7th of February, was very little affected by this last earthquake, whilst the town of Messina experienced a very severe shock, which considerably increased the injury occasioned by that of the 5th of February It would appear, therefore, that this earthquake followed a linear direction, keeping close to the ridge which unites the Aspromonte to the northern mountain-tract The scientific travellers, who visited Calabria a short time after the earthquake had occurred,

mention several circumstances which prove that the mountains had also been convulsed by the shocks According to the information they collected from the inhabitants and eye-witnesses, it appears that huge mountain-masses had been split asunder, and a portion of them removed to a considerable distance, that the summits of some of the granitic mountains had been seen moving up and down in quick succession, and that the layers of earth which covered the bases and lower declivities of these masses of rocks had been shaken from their situation, chasms formed between them and the bare rocks of several feet in width and many miles in length. It is to be regretted that those authors did not then ascertain by which of the three earthquakes the mountains had been disturbed in this extraordinary way It is probable that these changes were effected by the earthquake of the 28th of March

20. The manner in which the shocks of an earthquake are propagated has been compared with the ring-like waves produced by a stone thrown into a lake Such waves decrease in height in proportion as they increase in periphery So it is also with the central earthquakes In places which are near the centre the shocks are severe, in those which are farther removed from it they are smart, but gradually they decrease in violence, and at a certain distance they lose the power of putting in motion the solid surface of the earth. Beyond this limit the effects of earthquakes are only felt on those parts of the surface of the globe, which are covered with water The sea and lakes are still strongly affected, which is proved by their levels rising above the common water-mark Springs cease to flow for a time, or rush out with increased vehemence These facts must be borne in mind when we wish to form an exact idea of the extent of the countries which are affected by an earthquake

The earthquake which convulsed Calabria in such a frightful manner, did not extend to a great distance from their centre, but it was quite otherwise with that of

Lisbon. Its effects have been traced over a space which, according to a rough calculation, comprehended about fifteen millions of square miles, or nearly equal to one-twelfth of the area of the globe. Besides the greater part of Europe, that portion of Africa was affected by it which lies between the Mediterranean and Mount Atlas. The shocks passed the Atlantic, and we find that not only several parts of North America felt them, but also that the sea surrounding the Lesser Antilles was put in motion by these shocks

In many parts of Spain very severe shocks were felt, as in Madrid, Malaga, and other places. France was much less affected, and the motions of the earth do not appear to have extended beyond the Pyrenees. But the northern part of Italy experienced very violent shocks, especially Milan, which was shaken so strongly, that the inhabitants feared the whole city would be levelled to the ground The Lake of Como exhibited extraordinary commotions, and the mountain-region between it and the Lake of Geneva suffered very much, especially the town of Brieg, in the Valais, where several houses were thrown down, and the walls of a number of others were split. Nearly all the Alpine lakes of Switzerland had their water set in motion, that of Neufchâtel rose over its banks and flooded the adjacent country The Lake of Murten on the other side is said to have lowered its level by six feet, and to have retained this level Slight shocks were felt even to the north of the Alps, in Bavaria, especially at Augsburg. Farther north no shock was experienced, and the effects of the earthquake were limited to the waters of some lakes, which were put in motion, and to some springs. Thus the hot springs at Toplitz, in Bohemia, ceased for a minute to flow, and then burst forth with increased force. The commotion of the waters was even observed in some lakes of Sweden, among which Lake Wenern is particularly mentioned

Only at one place on our island was a shock felt. Near Ashford, in Derbyshire, the miners engaged in a mine felt such a strong commotion that they were

frightened, and thought the pit was falling in. In its vicinity a rent was formed in the ground which was nearly 150 yards long, about a foot deep, and six inches in width. The sea, however, was agitated round our islands On the coast of Cornwall it rose eight or ten feet above its common level, and many vessels were torn from their anchors and wrecked The commotion of the sea was rather stronger at Cork, but much less at Liverpool and in the harbours of Scotland In Essex some ponds overflowed their banks, and several of the lakes of Scotland, as Loch Lomond, Loch Ness, and Loch Kettuin rose several times from two to three feet above their usual level

The waves of the earthquake which proceeded to the south from Lisbon, appear to have acted with much greater force. We have already mentioned their effects on Cadiz, Ayamonte, and Gibraltar The Empire of Morocco was affected by them even more violently. All the larger towns, as Tangier, Tetuan, Fez, Mequinez, and Morocco were greatly damaged in their buildings. Not far from Morocco a large village was entirely ruined, and the whole population perished. In the harbour of Funchal in Madeira, the sea rose fifteen feet above its common level, and great was the damage caused by this inundation in the town

On the other side of the Atlantic the Lesser Antilles experienced an extraordinary rising of the sea Round Barbadoes, where the tide commonly rises only from twenty-four to twenty-eight inches, the sea rose on the first of November, at some places, twenty feet, and round Martinique and Antigua fifteen feet Round Barbadoes the water was as black as ink. Alexander von Humboldt is of opinion that this colour of the sea-water was derived from the petroleum, with which the bottom of the sea is covered between the Islands of Barbadoes and Trinidad, and which had been stirred up by the violence of the shocks In the United States smart shocks were felt at several places in Massachusetts and Pennsylvania The country surrounding Lake Ontario and the adjacent parts of Canada experienced also slight shocks It is remarkable

that at the last-mentioned places the commotions of the earth preceded the earthquake of Lisbon, as they were felt during the last days of October

An earthquake which extended over the whole of the Indian Archipelago occurred in 1816, and was noticed by Sir Thomas Raffles, then Governor of Java Its centre was in the island of Sumbava, where the shocks continued almost without interruption from April to June, and did not cease until after an eruption of the volcano of that island The number of persons who lost their lives by this earthquake, is in Sumbava alone stated to have exceeded twelve thousand The shocks extended over the Lesser Sunda Islands to the shores of New Guinea, and, in a north-eastern direction, over the different groups which are comprehended under the name of the Moluccas, they were also felt in Celebes, Borneo, and Java, and in a great portion of Sumatra The most distant place in the island of Sumatra, which experienced the shocks, was about nine hundred and fifty miles distant from its centre

21 Having described the nature of the motion, the direction in which the shocks spread over a country, the great extent of country which is sometimes affected by them, and the common effects produced by severe earthquakes, it remains yet to notice some of the phenomena commonly attending earthquakes, namely, the subterraneous noises, the chasms, the different kinds of matter issuing from these chasms, and the rising of the sea.

A subterraneous noise usually accompanies severe earthquakes, but not always. No noise was heard during the shocks which in 1797 levelled the town of Riobamba to the ground, and killed from 30,000 to 40,000 persons, and which is called by Von Humboldt one of the most frightful phenomena recorded in the physical history of our globe. A very loud noise issuing from under the ground on which the towns of Quito and Ibarra stand, frightened the inhabitants of these places, but it occurred eighteen or twenty minutes after the catastrophe had taken place by which Riobamba was destroyed, and even then no noise was heard at

Tacunga and Hambato, two places situated near the centre of the earthquake. The same absence of noise was noticed in Peru in 1746, when Lima and Callao were destroyed by an earthquake, whilst a quarter of an hour later a loud subterraneous noise, similar to a clap of thunder, was heard at Truxillo, which is more than 300 miles farther north, but at this place no commotion of the ground was perceived. In the earthquake at New Granada (1827), the shocks passed away without noise, but some time afterwards subterraneous detonations were heard, which followed one another at regular intervals of about thirty minutes, but were not attended with any convulsion In most cases the noise is heard when the earthquake begins, but in some it precedes the first shock by a few minutes or seconds

The sound of this noise is not in all places of the same description In most cases it is compared to a rumbling sound, produced by a continuous series of small explosions, not dissimilar to the rolling of thunder, or, when less intense, to the rattling of a number of carts passing at a distance over an uneven stone-pavement In Quito the sound frequently resembles abrupt broken peals of thunder Sometimes it is like the sound produced by iron chains, when they are violently shaken; and sometimes it is more shrill, as if obsidian and other masses of vitreous matter were broken to pieces with violence in subterraneous caverns

This subterraneous noise is sometimes heard, and apparently at the same moment, over an immense extent of country, a circumstance which has excited, with reason, the astonishment of the natural philosophers The best ascertained fact of this description occurred in the northern countries of South America in 1812, on the 30th of April, shortly before an eruption of the volcano in the island of St. Vincent. This noise, as Von Humboldt states, was heard in all the countries lying contiguous to the southern shores of the Caribbean Sea, and as far inland as the Llanos or Cattle Plains. At Calabozo, and on the banks of the river Apure, which falls into the Orinoco, it was apparently as loud as on the shores of the

sea Humboldt calculates, that the countries in which this noise was heard nearly at the same time and with the same degree of intensity, and without being attended with the least motion of the ground, had an area of about 60,000 square miles The two well-ascertained circumstances, that the noise was heard at the same time and with the same degree of intensity, are certainly very remarkable We must infer from them that the sound cannot have been propagated by the air, as it is well known that claps of thunder are only heard at distant places after a proportioned lapse of time Solid bodies are indeed much better conductors of sound than air. Thus burned earth propagates the sound quicker than air, in the proportion of ten or twelve to one But all the ascertained facts respecting the propagation of sound, by repeated experiments, are not sufficient to explain the two above mentioned It would seem that the noise originated in the interior of the earth, at a spot equally distant, or nearly so, from the surface of the globe at all the places where it was heard. A similar fact is mentioned as attending the great eruption of the volcano of Cotopaxi, in Ecuador, in 1744 At the moment of eruption or shortly before, a subterraneous thunder was heard at Honda, in the valley of the Rio de la Magdalena These two points are five hundred miles distant from each other, and between them are heaped up the colossal and immense mountain-masses of Quito, Pasto, and Papayan, with their numberless valleys and ravines. Besides, the summit of the volcano is elevated 18,000 feet above the site of the town of Honda

22 It is also remarkable, that sometimes, though rarely, a subterraneous noise is heard which is not connected either with an earthquake or with the eruption of a volcano. These subterranean thunders have been mentioned by ancient writers, but in modern times they have not been frequently observed. The most remarkable fact of this description occurred at the town of Guanaxuato, in Mexico, in 1784 At midnight, on the 9th of January, it was heard for the first time. It continued to increase by degrees from that day to the 13th,

it attained its greatest intensity It seemed then as if heavy thunder-clouds had gathered under the town, whence issued a slowly rolling thunder, frequently interrupted by short and extremely loud claps From the 16th of January the noise began to decrease, but it did not cease before the 12th of February No interruption took place during the whole time of its duration, no commotion of the ground was observed in the vicinity of the town of Guanaxuato, nor on any other part of the table-land of Anahuac, nor did it appear that any of the volcanoes of this table-land were in activity. What renders this phenomenon still more remarkable, is, that it was limited to a comparatively small extent of country, as people living at a distance of only twenty miles from the town did not hear the least noise But it was as loud in the numerous mines which are found in the vicinity of the town, and of which some are of the depth of 1,600 feet, as in Guanaxuato itself The inhabitants of the place, as may easily be imagined, were put into the greatest consternation They abandoned the town with precipitation, in which great masses of silver, drawn from the neighbouring mines, had been accumulated, and which were thus left without protection Some robbers, taking advantage of this circumstance got into the town and took possession of the treasures, but a number of the less timid of the inhabitants had meanwhile become habituated to the noise, and had in some degree got rid of their fright They re-entered the place, and regained possession of the treasures A similar subterraneous noise had never been heard in the country before nor has recurred since

Much less intense, but of much longer duration, was the subterraneous noise which frightened the inhabitants of Melida, a small island in the Adriatic Sea, not far from Ragusa in Dalmatia It was heard for the first time in March, 1822, and resembled the sound of a remote cannonade It did not continue uninterruptedly, but ceased sometimes for weeks and even months together, and then commenced again. Some of the detonations were attended by very slight shocks of earthquake. This noise did not entirely cease before 1826.

23. Hardly any account exists of a severe earthquake in which the formation of chasms, rents, and cracks, is not mentioned. These openings are commonly of a very considerable extent, but of moderate width. The number of such rents which were found in the plain of Calabria, after the earthquake had ceased, was very great; in the vicinity of Polistena, especially, they were so numerous that the roads were rendered impassable. During the earthquake which in 1805 happened in the province of Molise, in the kingdom of Naples, numerous chasms of considerable width and great extent had been formed, which for a length of time afterwards were still open. In 1818 the chasms opened by the earthquake in Catania, split the walls of the houses standing over them so widely that the moon could be seen through the rents thus produced, but immediately afterwards they closed so firmly that it was hardly possible to perceive any trace of them in the walls. The last-mentioned event, strange as it may appear, is mentioned in many accounts of earthquakes.

It is easily to be conceived in what way these chasms are formed. The crust of the earth consisting of solid matter, cannot yield like a fluid. When therefore it is raised upward, and at the same time affected by the undulatory shocks, its surface must crack and open. It may also be explained why some of these chasms remain open after the earthquake has passed away, whilst others close as soon as the motion ceases. The chasms of the first description are caused by the undulatory motion on a level tract, whose outer edge is formed by a steep and abrupt descent to a lower level. When such a tract has cracked and opened, the chasms are always found to run parallel to the outer-edge, and in most cases the perpendicular layer constituting the outer edge, which has no support on the side towards which it is propelled, is thrown down on the lower ground. This process has been the cause of much destruction. According to the account of Hamilton, the greatest part of the Pallazzata of Messina was precipitated into the sea, because the spot on which it was erected separated by a crack from the

contiguous ground, and as it had no support on the side next the sea, it tumbled into the Straits of Messina It is very probable that the stone quay of Lisbon was in a similar state before it gave way to the inundation Hamilton is also of opinion that most of the translocations of the pieces of ground, which on the borders of the deep ravines of Calabria had sometimes sunk twenty feet to the bottom of the water-courses, were effected in this way. By the downfall of the perpendicular layer forming the outer edge, the body is withdrawn by the reaction of which the other chasms which traverse the level ground parallel to the outer edge could be closed, and therefore these chasms remain open until they are filled up by the effects produced on the earth's surface by rain, water-courses, &c Houses, and other buildings, which are erected on such level ground, of course have their walls split by the change of level on which their foundations are laid and many are so ruined that they do not retain the least trace of their former shape

But when a tract of country is so constituted that none of its edges can give way, a place, we will suppose, enclosed on all sides by mountains, the effects of the shocks on its surface must be different The shocks, by raising the ground, make the surface crack and open, but, as soon as the force to which the earthquake owes its origin ceases to act, the surface sinks to its former position, and the chasms are closed Thus we may explain how it happens that during an earthquake rents are occasionally formed in buildings half a foot or even a foot wide, which however on the cessation of the motion close so firmly that it is impossible to discover the traces.

Another description of openings, owing their origin to earthquakes, are those which have the form of inverted cones They are sometimes several feet deep, and occur only in a soil which contains a considerable proportion of sand It is stated that during an earthquake hot water mixed with sand issues from these openings. The sand has a ferruginous appearance, and at first a smell of sulphur Such openings were numerous at several places in Calabria, and also on the banks of the Mississippi after the earthquake of 1812.

We find that different kinds of gas, smoke, fire, water, and in some cases more solid matters are frequently brought from the interior of the earth to its surface by earthquakes. It is remarkable that no chasms have been found at the places where these matters were ejected. We may easily comprehend, that the earth may emit gas, fire, and smoke without disclosing a rent in its surface, and so it appears it does During the earthquake of Lisbon a thick smoke was seen rising from the declivity of a rocky mountain, which continued for some time after the commotion of the earth had ceased, but when the place was afterwards inspected, no trace of a chasm could be discovered. Humboldt mentions, that during the earthquake of Cumaná (1797), flames issued at some places on the banks of the Rio Manzanares, but he does not mention that they had been emitted by cracks Water, however, and earthy matter cannot be brought from the interior of the earth to its surface without the formation of chasms; and we find that in several accounts this is expressly stated As these chasms, however, closed with the cessation of the earthquake, and have never been examined with attention, we have not the means of forming an idea of the manner in which they were made. It is probable that they reached to a much greater depth than the chasms we have noticed before.

24 Earthquakes bring several kinds of gas, vapours, smoke, flames, water, mud, sand, and stones from the interior of our globe to its surface Instances in which smoke and flames were seen issuing from the earth have been mentioned before. Water is said to have flown from the conical openings described in page 44, but in some cases it is stated to have rushed out of a chasm, and risen several feet in height like a fountain. The surface of the island of Jamaica, during the great earthquake of 1692, was deeply rent at several places, and these rents swallowed up several persons, but quickly re-opening ejected them again by means of jets of water, which rushed out of the ground with great violence, and rose to a considerable elevation. At the same time thick clouds of vapour issued from the chasms, diffusing an insupportable stench,

and for a short time obscuring the atmosphere to such a degree, that the air which, up to that moment, had been perfectly serene, suddenly assumed the appearance of a burning furnace. In the beginning of the last century (1702 and 1703), the provinces of the Abruzzi, in the kingdom of Naples, were visited by a very severe earthquake. The town of Aquila, among other places, was levelled to the ground. During this earthquake several chasms were opened in the fields surrounding that place, from which volumes of gas or steam rushed out, carrying with them such volumes of water, and such quantities of stones and earthy matter, as were sufficient to cover the fields in the neighbourhood, and to render them unfit for agricultural purposes for a number of years. The water ascended like a fountain, and rose so high that its summit overtopped the highest trees in the vicinity; flames and thick clouds of smoke were seen escaping from the neighbouring mountains, and these clouds continued for three days almost without intermission.

The ejection of mud appears to be of less frequent occurrence. Humboldt, however, mentions a very remarkable instance, which is connected with the great earthquake of Riobamba (1797). At a time when none of the neighbouring volcanoes ejected any kind of matter, a chasm opened, from which issued a very strange mass of mud, consisting of a mixture of charcoal, crystals of augite, and scales of infusoria. This mass, called *moya* by the natives, covered several fields, which were rendered sterile by this thick coat, and which formed besides a series of small eminences. A similar effect was produced by the earthquake of Valparaiso (1822). In the valley of the Quillota river, numerous hillocks, consisting of sand and mud, were forced through the crevices caused by the shocks. They appeared like mud-volcanoes in miniature, and some of them sunk again, leaving in their places muddy pools.

As gas is not visible, it is not frequently mentioned as issuing from the earth during earthquakes. But a learned Frenchman, who has given an account of the earthquake which occurred in 1827, in the valley of the Rio Magdalena, states that large quantities of carbonic acid gas

escaped from some crevices; and that a great number of snakes, rats, and other small animals living in holes in the earth, were killed by it. In several instances it has been observed that during an earthquake the surface of the sea, or even of a river, as for instance that of the Douro at the earthquake of Lisbon, was in a state of agitation not dissimilar to that of water in a high state of ebullition This phenomenon was also observed in the Straits of Messina during the earthquake of Calabria, and not far from the mouth of the Douro, in the sea during that of Lisbon. It is supposed that air or gas has escaped from the sea at such places

25 That gas occasionally really escapes from the bottom of the sea and reaches its surface during an earthquake, was proved by an event which took place in the harbour of Callao in 1828 A British vessel of war, the Volage, was anchored in that harbour with several other vessels The morning of the 30th of March was clear, and a light breeze came from the southward At half-past seven o'clock a thin black cloud passed over the ship, with very heavy distant thunder At the same moment the shock of a severe earthquake was felt Persons on board the vessel thought that it continued seventy or eighty seconds The ship trembled violently The commotion was compared to that which would have been felt, had the ship been placed on trucks, and driven with rapidity over coarse paved ground The ship was moored with two chain-cables, and, on raising the anchor a few days after, it was found that fifty-six links of the best bower cable were much injured, the iron had the appearance of being melted, and nearly one-sixth of each link was destroyed The part of the chain so affected was thirty fathoms from the anchor, and twenty fathoms from the ship The bottom was soft mud, in which the cable was buried During the earthquake the water alongside the vessel was full of bubbles, and emitted a hissing sound The city of Lima suffered considerably at the same moment, and a number of lives were lost. Such is the account of this remarkable fact. The damaged state in which a part of the chain-cable

was found, compels us to adopt the supposition that an expansive fluid or gas had escaped from the bottom of the sea, with a development of an uncommon degree of heat. It remains doubtful whether the gas escaped from a crevice or any opening in the bottom of the sea, but the small number of links which were affected by it appears to be rather in favour of the supposition

26. One of the most destructive of the phenomena accompanying earthquakes is the alternate rising and retiring of the sea. It does not appear that all great earthquakes are attended by this phenomonon In the accounts published of the earthquakes of Cumaná (1797), of Caraccas (1812), and of Valparaiso, no rise of the sea, either during the earthquake or immediately after it, is mentioned. Some state that this phenomenon occurred during the earthquakes of Calabria, but that is very doubtful, as Hamilton makes no mention of it, though he expressly observes that the inundation, by which a small portion of low land was covered, was caused by the fall of a rocky mass, detached from the mountains lying on the other side of the Straits of Messina, and the consequent high wave produced by its being precipitated into the sea. This author, who visited Calabria immediately after the earthquakes had ceased, could certainly not have overlooked this circumstance, as by rising twenty or thirty feet above its usual level, the sea would have rushed with great violence into the deep ravines by which the plain of Calabria is furrowed, and all of which are open to it. The rising of the sea, however, proved very destructive in the earthquakes of Lisbon (1755), and those of Callao (1585 and 1746) In Lisbon it caused the downfall of the stone quay, by which accident three thousand persons were drowned as mentioned before When the earthquake of Lima had ceased to agitate the ground, the sea rose in the following night about eighty feet above its common level in the harbour of Callao. It rushed with such violence over the place that everything was destroyed and washed away, and nothing remained standing except a few ruins of the fortifications. The population, consisting of about 5000

individuals, was drowned, with the exception of about 200. When the wave rushed into the harbour twenty-three vessels were at anchor there, four of them were carried by the flood over the walls of the fortress, and put down on the continent at a distance of about two miles from the shore, the other ships were broken to pieces.

Instances of earthquakes at sea are frequently recorded in the journals of navigators. In most cases the motion felt on board the vessel is compared with that experienced when a ship strikes on a rock under water. During the earthquake of Lisbon, an English vessel, sailing at a distance of about fifty miles from the coast of Portugal, experienced a shock of such violence that a part of the deck was damaged. The captain, greatly surprised, thought that a great mistake must have crept into his dead reckoning, and that his vessel had got on a rock. He gave orders to put out the long boat to save the crew, but he was soon convinced that there was no danger. Shaw, in his 'Travels in Barbary,' states that he experienced, in 1724, at a place where the sea was thirty fathoms deep, three severe shocks. It appeared to him as if great masses of stone, of from twenty to thirty tons in weight, had been thrown on the ballast. The Dutch navigator, Schouten, when navigating among the Moluccas, experienced frequent shocks when his vessel was out of soundings, and every time it appeared to him as if he had run aground. Le Gentil mentions that he once felt so powerful a shock that the guns of the vessel were put into a skipping motion, and part of the rigging was torn to pieces.

27. All the phenomena attending earthquakes hitherto noticed occurred in the last great earthquake of South America, that of Concepcion and Talcahuano, of which Captain Fitz Roy has given the following graphic description, which is the more valuable as it shows in what manner the shipping in the harbour of Talcahuano were affected by the alternate rising and retiring of the sea.

"At ten in the morning of the 20th Feb., very large flights of sea-fowl were noticed passing over the city of Concepcion, from the sea-coast towards the interior. In the minds of old inhabitants, well acquainted with the ch-

mate of Concepcion, some surprise was excited by so unusual and simultaneous a change in the habits of those birds, as no signs of an approaching storm were visible, nor any expected at that season About eleven the southerly or sea-breeze freshened up as usual, the sky was clear and almost cloudless At forty minutes after eleven a shock of an earthquake was felt, slightly at first, but increasing rapidly During the first half-minute many persons remained in their houses, but then the convulsive movements became so strong that the alarm was general, and all rushed into the open spaces for safety The horrid motion increased, people could hardly stand, buildings waved and tottered. Suddenly an awful overpowering shock caused universal destruction In less than six seconds the city was in ruins The stunning noise of the falling houses, the horrible cracking of the earth, which opened and shut rapidly and repeatedly at numerous places, the desperate heart-rending outcries of the people, the stifling heat, the blinding, smothering clouds of dust, the utter helplessness and confusion, and the extreme horror and alarm, can neither be described nor fully imagined

"This fatal convulsion took place about a minute and a half or two minutes after the first shock During this time no one could stand unsupported People clung to each other, to trees, or to posts Some threw themselves on the ground, but there the motion was so violent, that they were obliged to stretch out their arms on each side to prevent being tossed over and over Horses and other animals were greatly frightened, standing with their legs spread out and their heads down, trembling violently Birds flew about wildly

"After the violent shock had ceased, the clouds of dust which had been raised by the falling buildings began to disperse. People breathed more freely and began to look round them Ghastly and sepulchral was their appearance, had the graves opened and given up their dead the sight would have been scarcely less shocking Pale and trembling, covered with dust and perspiration, they ran from place to place calling for their relations and friends. Many seemed to be quite bereft of reason.

"Considerable shocks continued at short intervals, harassing and alarming. The earth was never long quiet during that and the next day; nor indeed the three days following the great shock For many hours after the ruin the earth was tremulous and the shocks were very frequent, though not severe. Many shocks, but not all, were preceded by a rumbling subterraneous noise like distant thunder, some compared the sound to the distant discharge of many pieces of artillery. These sounds came from the south-west quarter and preceded the shock by one or two seconds Sometimes, but not often, the sound was heard unaccompanied by any shock

"Roofs fell in everywhere Houses built of unbaked bricks fell into a confused heap. The cathedral, whose walls were four feet in thickness, built of good brick and mortar and supported by great buttresses, suffered more than other buildings. Adhering to the remains of the walls were the lower parts of some buttresses, the upper parts of others, while in one place a buttress stood on its own foundation, separated entirely from the wall

"The city of Concepcion stands on a plain, having an alluvial and loose soil, and at the back of it are rocky, irregular hills. From the foot of these hills the earth was everywhere parted by the great convulsion, great cracks being left from an inch to a foot in width. It seemed as if the low land had been separated from the hills, having been more disturbed by the shock. Besides a waving or undulatory movement, vertical, horizontal, and circular or twisting motions were felt. An angular stone pinnacle was particularly noticed, which had been turned half round without being thrown down or leaving its base.

"Persons riding at the time of the great shock were stopped short some with their horses were thrown to the ground, others dismounted but could not stand So little was the ground at rest after the great ruin, that between the 20th of February and the 4th of March more than three hundred shocks were counted."

"At Talcahuano the great earthquake was felt as severely as in the city of Concepcion. It took place at the same time and in a precisely similar manner. Three houses only, upon a rocky foundation, escaped the fate of all those standing upon the loose sandy soil which lies between the sea-beach and the hills. Nearly all the inhabitants escaped uninjured, but they had scarcely recovered from the sensations of the ruinous shocks, when alarm was given that the sea was retiring! As in former times a place in the bay of Talcahuano had been destroyed, with its whole population, by an overwhelming wave, preceded by a retiring of the sea, all became apprehensive of a similar fate, and hurried to the hills as fast as possible.

"About half an hour after the shock, when the greater part of the population had reached the heights, and the sea had retired so much that all the vessels at anchor, even those which had been lying in seven fathoms water, were aground, and all the rocks and shoals in the bay were visible, an enormous wave was seen forcing its way through the western passage, which separates Quiriquina Island from the main land. This immense wave passed rapidly along the western side of the Bay of Concepcion, sweeping the steep shores of everything moveable within thirty feet vertically from the high-water mark. It broke over, dashed along, and whirled about the shipping as if they had been light boats, overflowed the greater part of the town, and then rushed back with such a torrent, that almost every moveable which the earthquake had not buried under heaps of ruins, was carried out to sea. In a few minutes the vessels were again aground, and a second great wave was seen approaching, with more noise and impetuosity than the first. Though this wave was more powerful, its effects were not so considerable, simply because there was less to destroy. Again the sea fell, dragging away quantities of wood-work, and the lighter materials of houses, and leaving the shipping aground.

"After some minutes of awful suspense, a third enor-

mons swell was seen, between Quiriquina and the main-land, apparently larger that either of the former waves Roaring as it dashed against every obstacle, with irresistible force it rushed along the shore, destroying and overwhelming. Quickly retiring, as if spurned by the foot of the hills, the retreating wave dragged away such quantities of household effects, fences, furniture, and other moveables, that, after the tumultuous rush was over, the sea appeared covered with wreck Exhaustion appeared to follow these efforts Earth and water trembled. Numbers of the inhabitants now hastened to the ruins, anxious to ascertain the extent of their losses, and to save some money or a few valuable articles, which, having escaped the sweep of the sea, were exposed to depredators

"During the remainder of the day and the following night, the earth was not quiet many minutes at a time. Frequent, almost incessant, tremors, occasional shocks more or less severe, and distant subterraneous noises kept every one in anxious suspense Some thought the crisis had not arrived, and would not descend from the hills into the ruined town. Those who were searching among the ruins started at every shock, however slight, and almost doubted that the sea was not actually rushing in again to overwhelm them Nearly all the inhabitants, excepting a few who went on board vessels in the harbour, passed the night upon the hills, without shelter, and next day they began to raise sheds and huts upon the high ground, still dreading the sea It was said, and generally considered certain, that every dog at Talcahuano had left the town before the shock which ruined the buildings was felt

"In the harbour were three large whale-ships, a bark, two brigs, and a schooner, very near the town, in from four to seven fathoms, they were lying at single anchor with a good scope of cable. With the southerly breeze, which was rather fresh at the time of the earthquake, these vessels lay to seaward of their anchors, having their sterns towards the sea. At the appearance of the

first great wave all hands took to the rigging for safety. The wave came in an unbroken swell to the stern of one of the whale-ships, broke over and lifted her along without doing any material harm more than sweeping her decks, as the hatches were battened down and dead-lights shipped. The slack chain dragging over the mud, checked her gradually, as the first impetus of the wave diminished. Whirling her round, the water rushed out to seaward again, leaving the vessel stranded nearly in her former position From two fathoms, when aground, the depth alongside increased to ten, when the water rose highest during the last swell. The two latter waves approached and affected the shipping similar to the former—all withstood their force, though the light anchors were dragged. Some of the vessels were thrown violently against others, and whirled around as if they had been in the vortex of a whirlpool. Previous to the rush of waters, two merchantmen were lying a full cable's length apart, and after it had passed they were side by side, with three round turns in their cables. Each vessel had therefore gone round the other with each wave, the bow of one was stove in, to the other little damage was done. A small vessel was on the stocks, almost ready for launching, she was carried by the sea two hundred yards in-shore and left there unhurt. A little schooner at anchor before the town, slipped her cables and ran out in the offing as the water fell. She met the wave unbroken and rose on it as an ordinary swell Many boats put off from the shore before the sea retired; some met the advancing waves before they broke and rose safely over them, others, half swamped, struggled through the breakers.

"For several days the sea was strewed with wreck, not only in the bay, but outside in the offing. The shores of Quiriquina Island were covered with broken furniture and wood-work of all kinds, so much so that for weeks afterwards parties were constantly at work collecting and bringing back property During three days succeeding that of the ruin, the sea ebbed and

flowed irregularly and very frequently, rising and falling for some hours after the shock, two or three times in an hour.

"Two explosions or eruptions were witnessed whilst the waves were coming in. One in the offing beyond the island of Quiriquina, which appeared to be a dark column of smoke in the shape of a tower. Another arose in the bay of San Vincent like the blowing of an immense imaginary whale; its disappearance was followed by a whirlpool which lasted some minutes. It was hollow and tended to a point in the middle, as if the sea was pouring into a cavity of the earth. At the time of the ruin, and until after the great waves, the water in the bay appeared to be everywhere boiling; bubbles of air or gas were rapidly escaping; the water also became black, and exhaled a most disagreeable sulphureous smell. Dead fish were afterwards thrown ashore in quantities; they seemed to have been poisoned or suffocated; and for days together the shores of the bay were covered with fine corvinos and numerous small fish. Black stinking water burst up from the earth in several places, and at one the ground swelled like a large bubble, and then bursting, poured forth black, fetid, sulphureous water.

"It was ascertained that in Talcahuano the body of water reached twenty-five feet above the usual level of high-water. It penetrated into the first-floor rooms, and left sea-weed hanging to the remains of roofs or to the tops of broken walls. Those who watched the waves coming in considered them, while beyond the shipping, about as high as the upper part of the hull of a frigate, or from sixteen to twenty feet above the level of the rest of the water in the bay. Only those parts of the wave which encountered opposition broke until within half a mile of the beach, when the roar became appalling. At the time of the great shock the water swelled up to high-water mark on the sea-beach, without having previously retired. It then began to retire and continued falling about half an hour before a great wave was seen approaching. For some days after

the devastation the sea did not rise to its usual mark, by four or five feet vertically But this difference gradually diminished, till, in the middle of April, it amounted only to two feet between the existing and former high-water marks It was considered as a proof that the land had been elevated

"Wherever the invading waves found low land, the destruction was great, from those lands being in general well cultivated and the site of many houses The low ground lying at the bottom of Concepcion Bay were overflowed and injured irreparably, quantities of cattle, horses, and sheep were lost Similar effects in an equal or less degree were felt on the coast between the river Itata and Cape Rumena Large masses of earth and stone, many thousand tons in weight, were detached from the cliffs and precipitous sides of the hills It was dangerous to go near the edge of a cliff, for numerous chasms and cracks in every direction showed how doubtful was the support When walking on the shore, even at high-water, beds of dead muscles, numerous chitons and limpets, and withered sea-weed, still adhering, though lifeless, to the rocks on which they had lived, everywhere met the eye, as proofs of the upheaval of the land"

28 In countries where earthquakes occur frequently, it is commonly supposed that such unusual and powerful phenomena, which appear to shake the whole earth to its centre, cannot take place without being preceded by some signs In most parts they think that an unusual state of the atmosphere must precede each earthquake In Italy the opinion prevails, that long calms, an oppressive heat, and a foggy sky, are indices of the approach of an earthquake But besides that such a state of the atmosphere often occurs without being followed by one of these terrible events, it has been found by long continued and exact observation, and by comparing the phenomena of the air preceding earthquakes, in the numerous accounts of the most severe of them which have been published in the last and present century, that no connexion exists between the state of the weather

and the earthquakes Severe shocks have occurred in calms, and when gales were blowing, whilst the atmosphere was obscured with fogs, and when the sky was cloudless and a fresh breeze was agitating the air, whilst heavy rains poured down, and during storms of thunder. It is true that several of the severe earthquakes were preceded by a fog of a reddish appearance, but this phenomenon has not been observed previous to a much larger number which have occurred when not the least cloud could be observed on the whole vault of heaven

It cannot be maintained either that earthquakes occur only at certain seasons of the year During the last fifty or sixty years the naturalists have paid peculiar attention to the seasons when these phenomena occurred, and by comparing the lists thus collected, it was found that in the higher latitudes they occur at all times, but more frequently during the cold weather, especially about the equinoxes, either shortly before or shortly after them, the smaller number have occurred between the vernal and autumnal equinoxes In the intertropical countries a large majority have happened when the rainy season was about to begin or cease They are especially severe when the dry season has been so long protracted as to have injured the crops and the vegetation in general In South America it frequently happens when an earthquake follows a season of long drought and dearth, that rain is much more abundant after it than usual. In these countries, the native population, whose huts built of reeds are rarely damaged by earthquakes, and who have no fear of being crushed by the downfall of their habitations, preserve the remembrance of great earthquakes as joyful events, keeping festivals on their anniversaries, while the descendants of Europeans form processions and perform religious ceremonies to avert the repetition of such disastrous calamities In the Indian Archipelago the smartest shocks are felt when the monsoons change.

It has been observed in many cases that the weather becomes considerably colder after an earthquake It is

doubtful if the climate of a place can be changed by the occurrence of an earthquake, though Humboldt mentions a very remarkable instance of the kind In giving a description of the town of Quito, in Ecuador, he says " It is a fine place, but the sky is unpleasant and foggy, the mountains surrounding the town are clothed with a very scanty vegetation, and it is extremely cold The severe earthquake which, on the 4th of February, 1797, convulsed the whole country and killed between 35,000 and 40,000 persons, has proved disastrous in this respect also, for it has greatly changed the temperature of the air At present the thermometer commonly ranges between 4° and 10° of the scale of Reaumur (41° and 54½° of Fahrenheit), and rarely rises to 16° and 17°, whilst at the time of Bouguer (between 1730 and 1740) it usually ranged between 14° and 15° (63½° and 65¾°).

29 Many persons suppose that, before the beginning of an earthquake, noxious exhalations of an invisible description are emitted from the surface of the earth This supposition rests on the well-established fact, that several kinds of animals evince an uncommon degree of restlessness when an earthquake is approaching This is especially the case with the smaller animals which inhabit caverns and holes in the ground, as rats, mice, lizards, moles, and snakes They leave their holes and run about with trepidation Some even of the larger domestic animals participate in this restlessness, especially those which are gifted with a very acute organ of smell, as goats, hogs, and dogs The dogs as before stated, abandoned the town of Talcahuano before the first shock was felt Hogs in many places are considered as having a quicker presentiment of the approach of an earthquake than other domestic animals, so that timid persons, when they think that they have reason to anticipate an earthquake, pay particular attention to all the motions of these animals Horses and cattle also appear to be affected, but in a less degree

It appears also in some cases, that persons have been attacked by a kind of indisposition before the beginning of an earthquake The most common symptoms

are sickness, giddiness, attacks of headache, and depression of spirits It is asserted that an hour before the great earthquake of Lisbon reached the towns of Cadiz and Gibraltar, several of their inhabitants were attacked by fits of sickness

An Italian writer, after having given a detailed account of the earthquake which was experienced in the city of Naples, and more severely in the province of Molise, in 1805, adds "I must not omit in this place to mention those prognostics which were derived from animals They were observed in every place where the shocks were such as to be generally perceptible Some minutes before they were felt, the oxen and cows began to bellow, the sheep and goats bleated, and, rushing in confusion one on the other, tried to break the wicker-work of the folds, the dogs howled terribly, the geese and fowls were alarmed and made much noise The horses, where fastened in their stalls, were greatly agitated, leaped up, and tried to break the halter with which they were attached to the mangers; those which were proceeding on the roads suddenly stopped and snorted in a very strange way The cats were frightened and tried to conceal themselves, or their hair bristled up wildly Rabbits and moles were seen to leave their holes, birds rose as if scared from the places on which they had alighted, and fish left the bottom of the sea and approached the shores, where, at some places, great numbers of them were taken Even ants and reptiles abandoned, in clear day-light, their subterraneous holes in great disorder, many hours before the shocks were felt Large flights of locusts were seen creeping through the streets of Naples towards the sea the night before the earthquake Winged ants took refuge during the darkness in the rooms of the houses Some dogs, a few minutes before the first shock took place, awoke their sleeping masters by barking and pulling them, as if they wished to warn them of the impending danger, and several persons were thus enabled to save themselves

30 By far the greater number of earthquakes pass away

without leaving any traces of their activity. This may be said of all those which manifest themselves by slight, or even by smart, shocks Severe earthquakes usually destroy only houses and other buildings, and produce very slight changes on the surface of those tracts of land beneath which their force is directed These changes owe their origin chiefly to the chasms which are formed in the manner already described A few, however, among those which have acted with an uncommon degree of energy, have left more lasting testimonials of their occurrence, either by depressing a large tract of land below its former level, or by raising it considerably.

Depressions of small extent appear, however, to be more frequently effected Many accounts mention lakes being found at places which, before the earthquake, had presented a continuous level A great number of such lakes appear to have been produced by the earthquakes of Calabria, and of Jamaica In the accounts of the last-mentioned earthquake especially, many instances are adduced of the subsidence of tracts of ground, of a thousand acres and upwards in extent, which had sunk many feet below their former level, and had suddenly been filled up with water, forming new lakes

31 The elevation of the ground has still more attracted the attention of naturalists, because it attests more evidently the great force with which the cause operates which produces earthquakes We have reason to suppose that the solid crust of our globe is several miles in thickness How immense must be the force which tears it asunder and raises one part of it to a permanently higher level than it before possessed? Well-ascertained instances of such elevations are not wanted, several such were observed after the earthquake of Calabria In the small town of Terranova, not far from Oppido, some houses had been raised above their former level, whilst others had sunk under it But an old tower in this town was particularly noticed, which had been split from its summit to its foundation, and of which one-half had been raised about fifteen feet above the other half, though both pieces had remained closely contiguous. Near the

village of Cossoleto a farm-house, together with its outbuildings and adjacent fields, was found raised some hundred feet above its former site, and a water-mill was lifted many feet above the rivulet which formerly had moved its wheels

In Calabria, however, only small portions of the surface of the country were raised above their former levels But by the earthquake of Valparaiso, which in 1822 convulsed the western shores of South America from Valdivia on the south to Copiapò on the north, an extent of coast-line not less than fifty miles long was raised nearly three feet above its level, at some places the rocks on the shore were found to be four feet higher than they had been before It is reported that some places on which the fishermen, before the earthquake, had gathered a kind of shellfish adhering to the rocks, were, subsequent to it, projected above the sea-level even at high water In the vicinity of a small harbour called Quintero, people were accustomed to dig shells for lime-burning from a stratum four or five feet thick, which was found in the recesses of the rocks at a height of about fifteen feet above the sea This stratum, which evidently at some remote period had been submerged, as is proved by the layers of shells, but afterwards raised above it by one of the great convulsions to which this coast is frequently subject, was, by the earthquake of 1822, again raised at least three feet The harbour of Quintero had from about two fathoms and a half to three fathoms of water before the earthquake, but after it the bottom of the bay was found to be raised full four feet

In Captain Fitz Roy's account of the earthquake of Concepcion, he states, that the coast near the harbour of Talcahuano was raised about two feet and gives the facts which induced him to come to that conclusion He states further that the island of Santa Maria, which is not far off the coast, was upheaved nine feet He adduces many circumstances to prove this fact, among others, that the soundings had diminished a fathom and a half round the island

Since it has been known that earthquakes are power-

ful enough to raise the solid surface of the earth to a higher level, naturalists have paid much attention to this point, and the searching eye of the modern geologist has discovered many places where the formation and composition of the rocks show clearly that at some remote time they have been under water, and have been raised above it by some agency acting from the interior of the globe towards its surface Such evidences are also found in our island, where they have been observed especially on the coasts of the Hebrides, and on Jura and Skye

32 The greatest change recorded in history as produced on the surface of the globe by an earthquake occurred in our own times in Hindostan By an earthquake which happened in 1819, a large tract of country, not far from the eastern mouth of the Indus river, was submerged and converted into a lake, whilst an adjacent tract, still larger in extent, was raised considerably above its former level In the beginning of the present century, and for many years previous to that time, the eastern mouth of the Indus, called the Koree, no longer received the waters of that arm of the river which is called the Phurraun, as had formerly been the case Partly by some changes which had occurred in its course, and partly by artificial means, all the waters of this branch were absorbed before it reached the 24th parallel of northern latitude The Koree had thus been converted into an arm of the sea, between which and that part of the Phurraun which still preserved a flow of water, a sandy waste spread out about fifty miles in width On this waste, at a place called Sindree, was a custom-house station for the goods which passed from Scinde to Cutch, or *vice versa*, and for the protection of the merchandise a fort had been erected about 150 feet square On the 15th of June (1819) the district of Cutch was convulsed by a frightful earthquake, by which many hundred persons lost their lives, and almost all the solid buildings of the country were converted into heaps of ruins On this day great changes were effected on the sandy waste Towards evening the fortress of Sindree was inundated by a rush of waters, which ad-

vanced from the sea on the occurrence of a severe shock, and a few hours afterwards the whole country surrounding it, to a distance of sixteen miles, was converted into a lake. At the same time it was observed, that on the north of the new lake a kind of dike had been formed, which extended about fifty miles east and west, and which now constituted the barrier between the bed of the Phurraun branch of the Indus and the lake. This dike was called by the natives Ullah Bund, or God's Dike, to distinguish it from other dikes erected by artificial means on the banks of the Indus for the purposes of irrigation. These events passed almost unnoticed at that time, but eight years later information was brought to Bombay that the Phurraun branch of the Indus had, in 1826, returned to its ancient bed, breaking through the Ullah Bund, and had reached the Runn, so that its waters again entered the sea by the Koree mouth. This news induced Captain Burnes to examine the country and the changes it had undergone with great attention. He sailed over the lake, and found that the site of the ancient fortress was occupied by pools, except at one place, which was dry, because the stones of the ruined building had fallen so as to form a large heap. The water of the Lake of Sindree was sweet. The Ullah Bund rose about ten feet above its base, and consisted of soft clay and sand intermixed with shells. The channel, which the Indus river had scooped out across this dike, was about thirty-five yards wide and three fathoms deep, and a large volume of water passed through it to the Koree. Captain Burnes was astonished at finding that this so-called dike did not in the least resemble those dikes made by the natives to divert a portion of the water of the river to their fields. The Ullah Bund was not an embankment a few yards in width, but a table-land about fifty miles in length, according to the statement of the natives, and nearly sixteen miles in width, extending northward to the Roama Bazar, a commercial place in the vicinity of the Phurraun river. Its soil was impregnated with saline particles. In this part of Hindostan, therefore, a tract of country occupying probably

not less than seven hundred and fifty square miles, has been raised in our own times about ten feet above its former level, whilst south of it another tract, of perhaps six hundred square miles, for this is about the area of the Lake of Sindree, has been submerged by the same earthquake. These two tracts, taken together, are equal in extent to the county of Cornwall

33 We may here also appropriately notice one of the most interesting monuments of antiquity, which, on its face, bears undeniable signs of having been submerged under the sea, and having remained in that state for a considerable time, though now again above the sea-level. This monument is the ruins of the Temple of Serapis, in the vicinity of the town of Puzzuoli, on the northern shores of the gulf of Naples Up to the middle of the last century the study of antiquity had been confined to the reading of the classical authors, but it then began to be directed to remains of ancient buildings, temples, palaces, and other ruins The zeal developed by this change was at first directed to the discovery of such remains as still existed It was then noticed, that in the vicinity of Puzzuoli, hardly more than a hundred yards from the sea, three massive columns projected several feet above the ground The dimension of the portions above ground showed that the greater part of them was hidden An excavation was commenced, and when the earth had been removed the extensive ruins of a magnificent temple were revealed They consisted of the three columns above-mentioned, still standing, and a number of others, mostly of smaller size, lying on the ground, portions of a wall of solid masonry which enclosed the temple were also in good preservation The antiquary, the sculptor, the architect—all found something to admire Ancient authors and the older records of history were searched for the purpose of finding out the facts relating to the erection of this magnificent edifice, but in vain, nothing was discovered Those, however, who had studied the history of architecture, and made themselves acquainted with the changes in the style of that noble art from the earliest times, came to the conclu-

sion, after a minute examination of the ruins, that the Temple of Serapis had been erected probably in the time of the Emperor Augustus or his successor, and certainly not later than that of Hadrian This point was, therefore, pretty well settled The question next arose, at what time and in what manner had the temple been buried under such a mass of earth, as was found in excavating it That it was not rubbish produced from the ruins was evident at first sight, but the records of history were equally silent respecting this event In the ruins themselves an inscription of the third century after Christ was discovered, which proved that up to that period it had not been covered with earth

As soon as the ruins were inspected by naturalists a very extraordinary fact was discovered It was found that all the columns of marble, the larger as well as the smaller, those which were standing no less than those which were lying prostrate, were perforated by a shell-fish, the *pholades*, at an elevation of about fifteen feet above their bases, and that the holes made by these molluscs in the columns constituted a band about three feet in width This was in exact conformity with the habits of the pholades, which live a few feet only below the surface of the sea, making their cells in calcareous rocks, forming generally a narrow stripe on the face of the cliffs It was, therefore, concluded, and there remained no doubt respecting the certainty of this fact, that the sea-level at this spot must have been at some period at least eighteen feet higher than it is at present, and must have remained so for a considerable period to have afforded the pholades sufficient time to establish themselves in the columns of marble

How was this extraordinary fact to be explained? The temple could not have been built at the bottom of the sea, and naturalists were therefore compelled to assume that this part of the coast had undergone two changes since the third century A D. It must have been submerged, and have remained so for a considerable time, and at a later period it must have been raised again above the sea-level Such changes were not recorded

in any documents It was, therefore, impossible to know historically in what way they had occurred, and it was therefore left to the fancy and sagacity of natural philosophers to explain the facts in a satisfactory way

The first authors who touched on this subject thought that the matter could be explained by assuming that the level of the sea had first been raised, and afterwards subsided They fancied they had discovered a proof of these changes in the traditional accounts of the irruption of the Black Sea into the Mediterranean, when the Straits of Constantinople and those of the Dardanelles were opened by some unknown cause This change must of course have considerably elevated the level of the Mediterranean, and this time, according to their opinion, the temple was immerged in the sea At a much later period, according to tradition, the Mediterranean was united to the Atlantic by the disruption of the rocky masses which closed the Straits of Gibraltar, it then sunk again to its former level, and the temple re-appeared This explanation was considered as satisfactory for a much longer time than it deserved, for it was utterly impossible to bring it in accordance with historical facts, or with the laws of nature For if the traditional accounts respecting the formation of the Straits of Constantinople, of the Dardanelles, and of Gibraltar were really true, they must have occurred more than a thousand years before the time when the Temple of Serapis was erected So far for history Next, according to the well known laws of hydrostatics, no part of a sea or of any sheet of water can be permanently raised above its former level, unless the whole of it be equally elevated If it could be imagined, even, that such a change had only affected the level of the Mediterranean, the effects of it must have been perceived on all its coasts The numerous towns built on its shores must have been inundated and destroyed, a fact which would certainly have been observed and recorded by the early historians, in whose writings, however, not the slightest allusion to such a change has been discovered

When this theory was exploded, the matter might have been settled in a satisfactory manner if it had been assumed that the part of the coast on which the temple was built had been first depressed and afterwards raised. But up to that time the effects of earthquakes in raising or depressing a part of the solid surface of the earth had been overlooked by naturalists Some instances of the kind were certainly known, but they had only affected very small tracts, and philosophers did not think themselves authorised by them to conclude that earthquakes could produce such extensive changes as were required to explain what had evidently happened to the temple Another hypothesis was broached It was suggested that when the temple fell into ruins, the rubbish had accumulated around the building, so as to form a small basin It was next assumed that the basin thus formed had been filled with sea-water by some extraordinary phenomenon, as, for instance, an exceedingly heavy gale, and that it had thus been converted into a lagoon filled with salt water. A third step in the theory brought by accident some pholades into the lagoon, which established themselves in the columns of marble, and then, as a conclusion to the series of assumptions, the lagoon, after subsisting for some centuries, was filled up with earth detached from the adjacent hills, and which covered the temple to the height already stated

This hypothesis, though it rests on four suppositions, none of which can be considered as *very* probable, was prevalent up to a recent period, and was supported by some authors of great celebrity, but has now lost its credibility by the close examination to which some geologists have subjected the site of the temple and the adjacent country These investigators found no trace of a lagoon ever having existed there On the contrary, they found that the adjacent shores, to the extent of more than a mile, bore evident signs of having been covered by the sea for a considerable time The coast there is formed by a narrow strip of low ground, backed by a more elevated tract, which rises from it with a steep acclivity The lower tract is composed of layers of

earthy matter, loosely united and uniform in its composition These layers contain numerous remains of ancient buildings, as pieces of brick, marble, granite, and porphyry, also fragments of vessels of earthenware. On the top of these earthy layers lies a stratum of fine sand, resembling in every particular that which is found at the bottom of the Mediterranean With this sand are mixed up numbers of well-preserved shells and muscles, all of them of species of frequent occurrence in that sea at the present day The lower layers of this tract show that they were once inhabited and built on, while the upper have evidently been formed at a long subsequent time That this layer was deposited at the same time when the columns were perforated by the pholades, is evident from the circumstance that it is found nearly at the same elevation above the sea-level with the upper border of the band which contains the holes made by the pholades

The discovery of these facts led to the opinion which at present begins to prevail, that part of the coast of the bay of Baia—for so this portion of the gulf of Naples is called—on which the Temple of Serapis stands, was submerged by an earthquake, and after having rested below the level of the sea for centuries, was again raised above its level by another earthquake The changes which have been produced on the surface of the earth by such phenomena, especially those on the coast of Chili, already mentioned, render such a supposition very probable It is true that such a subsidence is not recorded in the historical documents, but as hardly any trustworthy accounts have been transmitted to us of what passed in these countries in the tenth and part of the eleventh centuries after Christ, when these coasts were frequently laid waste by the incursions of the Saracens, we can hardly be surprised at the total want of historical notice respecting these changes This want, however, may be considered as fully supplied by a number of other facts which prove beyond all doubt that the whole coast of the bay of Baia has undergone great alterations since the time when it contained the most frequented watering

places of the Romans, and was resorted to by them as we now visit Brighton, Ramsgate, or Margate, that by these changes considerable tracts of land, which were formerly embellished with country-houses, extensive baths, and other sumptuous buildings, have been immerged in the sea by some catastrophe of which history has left no record This fact is proved by the existence of a great number of ruins at the bottom of the sea about fifteen or twenty feet below its level When the sea is calm, they may be clearly distinguished They consist of pedestals of whole rows of columns, of stair-cases of stone descending into the depths, of arches; of gates, doors, and windows Two Roman roads are also discerned, one leading from Baia to Misenum, the other from Puzzuoli to the Lake of Lucrino It can therefore be scarcely doubted that a subsidence of a large tract of country has taken place on these shores at a comparatively modern period

The subsidence of the Temple of Serapis must have happened during the obscurity of the middle ages, when our historical information of Southern Italy is extremely scanty, but as the rise of the country must have evidently taken place at a much later period, that has probably happened in times of different character Still there is no mention made of it by the later historical writers It is therefore supposed to have happened when the attention and thoughts of the inhabitants of this part of Italy were absorbed by some event of uncommon interest Such an event was the formation of the Monte Nuovo, which, after a long continuance of frequent earthquakes, was thrown up (in 1538) at a place but a very few miles distant from the site of the temple This event, which spread terror among the population of the country, probably made persons overlook the small tract in the vicinity of the newly created mountain which had been raised from the sea It is stated that some documents have been lately discovered referring to that period by which a tract of land along the coast, *which had been abandoned by the sea*, was ceded by the government to some ecclesiastical corporation.

In this hypothesis, it is supposed that the subsidence of the Temple of Serapis was affected by an earthquake, and suddenly, but it is possible that the piece of ground on which it stands had subsided slowly, gradually, and without any convulsion of nature Such an event would certainly be in accordance with the changes which the site of the building is undergoing at present It is beyond all doubt that the foundation of the temple is now subsiding, and has been for many years past The author of this work visited the temple in 1813 and in 1819 At his first visit the area included by the walls surrounding the temple was everywhere quite dry, and did not appear to have been under water for a long time before At his second visit he was astonished at finding nearly the whole of the area inundated, and in some parts the water more than two inches deep The sea had got access to it, and government about this time found itself obliged to take some measures to keep the water out, but which were not attended with the desired effect As it now became evident, that either the sea was rising, as it was supposed by some, or that the ground was subsiding, as others thought, a hydrometer was erected within the precincts of the temple in 1822, to enable those interested in the matter to mark the progress of this extraordinary phenomenon In 1839 a paper was published at Naples, in which a detailed account of the rise of the sea within the temple is given, the result of which is that in sixteen years, i e, from 1822 to 1838, the level of the water has risen 111½ millimetres, or nearly four inches and a half Such are the facts which prove that along this coast of the Mediterranean a small tract of ground is really subsiding gradually and continually, as a number of other observations published in our times have a tendency to convince us that the northern part of Scandinavia is actually rising also, gradually and continually, but much more slowly The force by which such changes are effected cannot be reasonably considered as proceeding from any other source than the interior of the globe, where is also seated that power which produces earth-

quakes and all the frightful phenomena accompanying them

34 The source whence earthquakes spring, the power by which the ground under our feet is convulsed, is withdrawn from our investigation The eye of the most inquisitive naturalist cannot reach it He must content himself with contemplating and examining the phenomena which are exhibited by that unknown force on the earth's surface, and with attempting to trace them backward to their origin That which strikes him first and instantaneously, is the immense energy with which this subterraneous power acts It is beyond all comparison greater than all the forces of which he has acquired any knowledge by experience If he investigates the phenomena still further, and especially the substances which are brought by earthquakes from the bowels of the earth and deposited on its surface, it must strike him that all of them bear evident signs of having endured the action of fire, and that some of them cannot have attained the state in which they appear without having been exposed to an intense heat Such observations intruded themselves, as it were involuntarily on the notice of the ancient philosophers, and we find therefore that the Greek and Roman writers frequently express the opinion that earthquakes were brought about by a force originating in a mass of fire, which fire they imagined to compose the nucleus of our globe

This opinion, ascribing the origin of earthquakes to a central fire in the bowels of the earth, prevailed from the most ancient times to the middle of the last century, when the study of electricity was pursued with great zeal, and this department of science was enriched by numerous discoveries. The theory was then started that the origin of earthquakes must be looked for in electricity According to this hypothesis, electric matter accumulated by degrees on the surface of the earth to such an extent, that the difference between the electric state of the globe and that of the surrounding atmosphere became extreme, and then the equilibrium between these two contiguous bodies could not be re-established without

a violent explosion and concussion, and this was an earthquake The whole phenomenon was therefore compared to a thunder-storm, and the shocks to powerful lightning. This hypothesis had certainly a great degree of probability to recommend it. For it cannot be denied that there exist many analogies between the phenomena accompanying thunder-storms and those of earthquakes, such as the extraordinary quickness with which either of them is propagated over immense tracts of country, the concussions of the air and of the earth's surface, the thunder accompanying the lightning, and that which is commonly heard when a severe shock is felt, the smell of sulphur which has sometimes been observed to attend both phenomena, the sultry weather which precedes, and the coolness of the air which commonly follows, them. It may even be assumed, that the restlessness which manifests itself in several kinds of animals shortly before an earthquake takes place, is produced by the different states of electric matter in the two bodies, the air and the earth It may easily be imagined that a theory by which such a number of phenomena could be explained, and which besides was founded on a branch of science which for a length of time constituted the favourite study of philosophers, soon gained ground and in a short time became generally considered as perfectly satisfactory. But when this theory was more closely applied and examined, great difficulties were met with It was found impossible to explain the manner in which such large masses of electric matter could be accumulated on the earth's surface without being conducted away, enfeebled, and dispersed, by the numerous caverns and chasms in the earth, whose sides always contain a great deal of moisture It was found equally incomprehensible why the shocks, by which the equilibrium of the electric fluid in the air and in the earth was re-established, should extend over such immense distances and in general follow certain directions. But the most decisive objection against the electric theory of earthquakes is the frequent repetition of the shocks and their long continuance, and which at some places has lasted for years together

Modern philosophers have therefore returned to the central fire of the ancients The existence of this fire was merely imaginary with the ancients, but our naturalists have ascertained some facts, which, indeed, cannot prove its existence, but which give some foundation to the hypothesis The most important of these facts is the increase of the temperature of the earth in proportion as we descend and get farther from its surface This fact has been constantly observed in those mines which descend to a great depth below the surface of the earth It is also confirmed by the water brought up by artesian wells from different depths The deeper the stratum lies from which the water is obtained, the warmer it is The numerous facts of this description which have been collected have suggested the idea, that we shall find the temperature of the earth continually increasing the farther we succeed in getting below its surface, and that at last we shall arrive at a point where we shall be compelled to stop, as the heat will be greater than the human frame can bear If we could approach nearer to the centre of the earth, we should probably at some distance farther arrive at a depth where the solid matter of the earth gradually passes into a fluid, consisting of a mixture of all kinds of matter melted by the excessive heat proceeding from the centre At what distance from the surface of the earth this heated fluid exists we have no means of determining We are not able to estimate the thickness of the earth's crust, as the solid portion of it may be called The heated fluid enclosed by this crust, however, is considered as the part where that power originates which produces earthquakes If the earth's crust was everywhere of equal thickness, it is probable that all parts of its surface would be equally affected by these phenomena. This, however, is not the case It has been before stated that some countries are visited frequently by these frightful phenomena, and apparently convulsed to their very foundation, whilst others suffer rarely, and experience only slight shocks The earth's crust must therefore be of different thicknesses. As it is also found, that most of the severer earthquakes are propagated in a linear direc-

tion, and at each occurrence always take the same direction, it is supposed that below such countries as are frequently convulsed by them, the earth's crust is split by wide chasms, whose wider opening is directed towards the heated central fluid, and whose narrower opening pierces the earth's crust to within a short distance from its surface Into these chasms the elastic vapour, which is supposed to be developed from the surface of the heated fluid, escapes, and in the progress of time is there accumulated and compressed When this accumulation of the elastic vapours (air, gas, or steam) has continued to go on until the chasm is overcharged, or when their expansive force is suddenly increased, they will seek to escape, and will act on the sides of the chasms with a force of which we can have no conception The lateral sides of the chasm, being composed of very solid matter, will powerfully and effectually resist this pressure, but the layer of solid matter which lies between the upper termination of the chasm and the surface of the earth will be less able to resist It will be convulsed by the elastic fluids, whilst they are forcing a passage to the atmosphere Thus earthquakes originate As, however, only a small portion of the enclosed elastic vapour can escape at each shock, these shocks are commonly repeated, and sometimes follow each other very quickly and for a length of time They probably do not cease until the quantity of the elastic vapour compressed in the chasm is so reduced that it can freely circulate within its boundaries.

Some of these chasms, and probably those of the largest dimensions, are united with the atmosphere by one or more openings, by which elastic vapours find a ready way to escape Such are the volcanoes They may be considered as safety-valves for the countries in which they lie • For as long as the compressed elastic vapour can escape, the countries in the vicinity are free from earthquakes But it sometimes happens that these safety-valves get out of order, their openings being blocked up by the accumulation of earthy matter or otherwise. Then the countries in their vicinity are con-

vulsed by earthquakes until the aperture or chimney has been re-opened by an eruption.

Connexion between Earthquakes and Volcanoes

35. The theory just expounded brings volcanoes into a close connexion with earthquakes The facts which in modern times have been collected to prove this connexion are so numerous and so comprehensive, that hardly any doubt remains respecting this point, which may be considered as having been nearly established It is true, that all severe earthquakes are not followed by an eruption This may be ascribed to the circumstance that there are many large chasms in the earth's crust which are not provided with a safety-valve, and Von Humboldt sagaciously observes that those earthquakes which last with little interruption for several weeks and months occur only in countries which are far distant from active volcanoes In such earthquakes the elastic vapours are supposed to escape by some of the rents formed during the continuance of the convulsion, and as such rents do not appear to have a great capacity, the accumulated quantity of elastic matter can only escape by repeatedly convulsing the surface But though all earthquakes are not succeeded by an eruption, eruptions are commonly preceded by earthquakes It is true that many eruptions of volcanoes have occurred which were not preceded by those phenomena to any extent, but that is only the case when the eruptions of a volcano follow each other at such short intervals that the canal between the elastic vapours under the earth's crust and the atmosphere has remained open, and time has not been allowed for choking it up Whenever this canal has been closed, which is indicated by smoke no longer issuing from the crater of the volcano, earthquakes may be expected , and it has been observed that the shocks of these earthquakes are the more severe, and extend over a larger tract of country, and the more energetic is the volcanic paroxysm which follows the longer the cessation has endured. Earthquakes continue to occur, and their shocks increase in number and intensity, up

to the very moment that the canal of the volcano has been re-opened, and the volcanic matter begins to flow from the crater, or the elastic vapours have again forced a free passage to the atmosphere When that has taken place the earthquakes cease, and are no longer felt in the countries surrounding the volcano Persons, however, who wish to have a near sight of the eruption, and who for that purpose ascend the volcano whilst it is in activity, feel that every new eruption of matter is preceded by a slight shock, whose intensity is proportioned to the time which passes between the shock and the flow of the volcanic matter

These facts are universally known in all those countries in which active volcanoes are found In the towns of Naples, Messina, and Catania, it is an opinion generally diffused among the population, that there is not the least fear of an earthquake as long as the smoke freely escapes from the craters of Mount Vesuvius and of Mount Etna. The same opinion prevails in Ecuador The inhabitants of the elevated valleys of Quito and Hambato residing round the bases of the volcanoes, Tunguragua, and Cotopaxi, dread the visitation of an earthquake, when, for any length of time, no smoke has been seen rising from their craters, and they are firmly convinced that the earthquakes, which have so frequently proved destructive to their country, will entirely cease as soon as the porphyritic cupolas of Mount Chimboraço shall have been removed, and thus a free exit been formed for the escape of volcanic matter or vapour

36 In all the cases just noticed the connexion between earthquakes and volcanoes is so evident, that it hardly admits of any doubt. But a number of facts have been collected which evidently show that there must exist a subterraneous connexion between these phenomena, even when they occur at great distances from each other Some of these facts are very interesting and curious Strombolı, a small volcano situated on one of the Lipari Islands, which is in continual activity, and never ceases to eject volcanic matter and smoke, fell suddenly into a state of inactivity, when, in 1783, the plain of Calabria was visited by the

great earthquake. The distance between the volcano and the centre of the earthquake does not much exceed fifty miles. Humboldt mentions that for many months the volcano of Pasto had uninterruptedly continued to emit a column of thick smoke, which suddenly disappeared on the 4th of February, 1797, just at the moment when the valley of Hambato was convulsed by the earthquake which levelled the town of Riobamba to the ground. In this case the distance was two hundred and twenty miles. On the 1st of November, 1755, a whirling column of smoke ascended from the crater of Mount Vesuvius, which is commonly a sign that the volcano is in a state of disturbance, but all at once the flow of smoke was stopped, and that which had issued re-entered the crater The distance between Lisbon and Mount Vesuvius exceeds one thousand two hundred miles As it is a well-established fact that the strong oscillation of the earth during the great earthquake of Lisbon extended to the centre of England, Lombardy, and the Alps, and even to Massachusetts and Pennsylvania, it can hardly be considered a bold assumption, when it is supposed that this change in the crater of Mount Vesuvius was effected by that earthquake

37. These events, though they occurred at great distances from each other, were simultaneous, and it was this last circumstance which first suggested the idea of there being a natural connexion between them When the supposition of this connexion was considered as founded on a well-established base, naturalists began to think it probable that such a connexion might exist between these two phenomena, even when they occurred at still greater distances than those mentioned, and not quite at the same time In such cases, however, the earthquakes must precede the eruptions of the volcano. It was thought probable that earthquakes might often continue to convulse extensive countries, until the bowels of the earth were relieved, by the eruption of a volcano, from the burden that oppressed them, though this volcano might be situated at a considerable distance from the places most severely affected by the

convulsions. Against this hypothesis it was objected, that the greater number of earthquakes had occurred in countries and places far removed from the vicinity of any active volcano, and near which not even the traces of an extinguished crater have been discovered. Such places and countries are Lisbon, Syria, Caraccas, and the valley of the Mississippi River Humboldt even acknowledges that he does not know of any severe earthquake, which has continued to convulse the surface of an extensive country almost daily for many months in continuation, except such as have taken place at great distances from any active volcano He observes that there was no neighbouring volcano to the earthquakes which, in 1808, visited the country lying on the eastern declivity of the Alps, at the base of Mount Cenis, round Fenestrelles nor to Pincrolo; and that which convulsed the central part of the valley of the Mississippi between New Madrid and the Little Prairie (south of Cincinnati) in the first months of 1812 A similar occurrence of a number of severe shocks happened in 1822 in the Pashalic of Aleppo These facts at first sight appear to militate against the opinion of a subterraneous connexion between earthquakes and volcanoes, when the first occur at great distances from the site of the volcanoes, but on maturer consideration it is found that they are in fact favourable to that hypothesis For if it be true, as is now almost universally supposed, that earthquakes are only produced by the efforts made by the accumulated elastic vapours to escape from the bowels of the earth, we can easily comprehend that such efforts must be most violent, or be continued for the greatest length of time, at such places as are distant from those openings in the surface of the earth (the volcanoes) where the discharge of the elastic vapours may be readily effected. The greater the distance between the volcano and the place of the earthquake, the severer must be the shocks, and the longer the convulsions must last, the later also will the confined elastic vapours reach the place where they can escape into the atmosphere.

38. As these facts prove the above-mentioned subterraneous connexion between earthquakes and the erup-

tions of volcanoes at least probable, even though at great distances from each other, philosophers have tried to ascertain the supposed connexion which existed between two real events of this description, by comparing the times in which they took place. Humboldt even thinks that when two places, lying at great distances from each other, experience severe earthquakes at two periods not separated from each other by many months, and when this event takes place repeatedly, we may suppose that there exists a connexion between them. To elucidate his opinion he notices the earthquakes by which the towns of Guatemala, in Central America (13° 28′ N. lat.), and of Lima, in Peru (12° 2′ S. lat.) have been damaged.

At Guatemala.	At Lima.
30th Nov., 1577,	17th June, 1578,
4th March, 1679,	17th June, 1678,
12th Feb., 1689,	10th Oct., 1688,
17th Sept., 1717,	8th Feb., 1716.

These earthquakes, as it is evident, take place at long intervals of time from each other. When we compare the periods at which they occurred at the two places, which are nearly two thousand miles distant from each other, it would seem that each couple of them were produced by the same force, which proceeded slowly along the mountain-ranges which lie between the two places, sometimes from north to south, and at others from south to north.

39. Less doubtful than in this case appears to be the connexion between some events which occurred in South America and the adjacent islands in 1797. In the beginning of that year the elevated table land, in Ecuador was visited by that frightful earthquake, which levelled to the ground the town of Riobamba, and destroyed a great number of villages. The number of persons who perished by it is stated to have amounted to 40,000. Most of them were buried under their houses, but many also were swallowed up by the wide chasms occasioned by the earthquake, while others were drowned in the lakes, which filled up such tracts as had subsided below their former levels. This event took place on the 7th

of February Hardly had these concussions ceased, when the inhabitants of the Lesser Antilles were frightened by severe shocks, which kept them in a continual state of uneasiness for eight months, and did not cease until the volcano of Guadaloupe, which had been inactive so long that it was considered as extinct, forced its crater open, and ejected lava and other volcanic matter on the 17th of September But it appears, that even by this eruption the subterraneous pressure was not entirely removed, as shortly afterwards several severe shocks were experienced in the northern countries of South America, which at last terminated, on the 14th of December, with the destruction of the town of Cumaná

40 A more extensive series of earthquakes and volcanic eruptions, apparently connected with each other, took place in 1811 and 1812, in the countries surrounding the Columbian Sea The subterraneous force first tried to open a vent by means of a submarine eruption in the Atlantic Smart shocks of earthquakes were for several days felt on the island of St Miguel, one of the Azores, and on the 30th of January (1811), large volumes of smoke, with which flames were observed to mingle, were seen issuing from the surface of the sea, at a distance of a few miles from the western coast of the island They threw up mud, stones, and other matter, which in a short time accumulated so as to form a small island, called Sabrina, but which after the lapse of a few months disappeared in the sea Not long after this event the Lesser Antilles, which are 2400 miles distant from the Azores, experienced very severe shocks, these were extremely frequent on the island of St Vincent, more than two hundred having been counted in the space of one year, from May, 1811, to April, 1812 In December, 1811, whilst the Antilles were still convulsed by repeated earthquakes, the first shocks were felt in the countries along the lower course of the Mississippi, whence they gradually extended northward, so that in February, 1812, the countries between New Madrid and the Little Prairie experienced, more or less, smart shocks every day, and at some places almost every hour Nearly about the same

time (in December, 1811) when the first earthquakes were felt on the banks of the Mississippi, the town of Caraccas experienced the first shock. It was not attended by destructive effects, but three months later the town was levelled to the ground by that frightful earthquake of which we have given an account Other shocks followed until the 5th of April At the end of the same month the volcano of St Vincent, from which there had been no eruption since 1718, was opened with a tremendous explosion, and by this it appears the bowels of the earth were sufficiently relieved from the burden that pressed on them, for after the eruption the earthquakes in South America and the Antilles ceased, and those in North America gradually decreased, until they also ceased entirely in the beginning of 1813

41 These facts, and still more the circumstance of eruptions of volcanoes being commonly ushered in by earthquakes, attest the close connexion existing between these two phenomena The more remarkable it must appear, therefore, that the substances which are brought from the interior by earthquakes are different from those which are ejected by volcanoes. Those which issue from the chasms made by earthquakes, as we have mentioned, are water, sand, mud, and stones, whilst those derived from volcanic eruptions, are lava, pumice-stone, cinders, ashes, and sand Though sand is mentioned as being thrown up by both phenomena, it is essentially different, that ejected by volcanoes consisting mostly of particles of lava in the minutest degree of comminution. Lava never appears to have flowed from any fissure originating in an earthquake It is indeed mentioned in Strabo, that after the island of Eubœa had been visited by a long continuation of earthquakes, a wide chasm was formed in the plain of Lelantus not far from Chalcis, from which a stream of heated mud ran out This by some writers has been interpreted as lava, but as no such fact has been noticed in modern times, the fact remains doubtful, and it is not improbable that it was much similar to the moya in the plain of Hambato, which we have before mentioned.

42 The quantity of matter is not generally large, which issues from the fissures of the ground during earthquakes; though, if the nature of the ejected matter is to be taken as a criterion between volcanic eruptions and earthquakes, we are compelled to ascribe to the last-mentioned phenomenon the formation of hills of considerable elevation, such as the Monte Nuovo, on the shore of the gulf of Naples, not far from Puzzuoli According to the accounts which have been transmitted by several eye-witnesses, the countries situated on the shores of this gulf had been convulsed for two years by severe earthquakes, when it was observed that, in the vicinity of Lake Averno, the ground had a peculiar motion, it split in many directions, and from the fissures issued water and flames, the sea receded from the shores, and a considerable tract along them was left dry This happened on the 28th of September, 1538 On the following day solid matter, accompanied by smoke and flames, began to issue, and in such quantity that in the space of two days the hill attained nearly its present size and elevation For though on some of the following days it received further additions, yet they appear to have been inconsiderable In these accounts no lava, or any other volcanic matter, is noticed This omission cannot be ascribed to a want of knowledge, as every inhabitant of Naples is well acquainted with lava, pumice-stone, scoria, &c The correctness of these accounts is also confirmed by the actual state of the hill, for it is composed of earth and fragments of conglomerate, without any mixture of lava or other volcanic production We must therefore consider this hill as having been formed by the matter issuing from a wide fissure made by an earthquake, without the intervention of volcanic action, though it resembles a volcano so far as to have in the centre a wide depression, similar to a crater, but the resemblance between the Monte Nuovo and a volcano is limited to this particular alone Its most elevated part is about 440 feet above the sea-level, but the depression in the middle sinks so deep, that its bottom is little more than 60 feet above the sea.

The circuit of this crater is somewhat more than 1600 feet, while the base of the hill has a circumference of more than 8500 feet

Nearly in the same manner and by a process very similar to that which threw up the Monte Nuovo, three hills were formed during an earthquake on the island of Lanzarote, one of the Canaries, in 1828 In the middle of the month of July some slight shocks of an earthquake were felt in the country about Tao, Tiagua, and Teguire, nearly in the centre of the island, and north of the crater formed in 1730, which is called Fire Mountain (Montaña del Fuego) On the 31st of July, when it grew light, some severe shocks were experienced, more particularly in the vicinity of Tao It was soon discovered that the surface of the country, which is nearly a level, had been split at several places At the same moment a dull subterraneous noise was heard, and it was found that all the water contained in the reservoirs of Tiagua had disappeared A few hours later a column of thick smoke was seen rising from the plain, whilst the shocks were increasing in number and intensity to such a degree, that the inhabitants were thrown into the utmost consternation The crevices in the ground were gradually widening so as to form spacious abysses, out of which smoke and fire were continually issuing Stones of considerable size were hurled out of them They were thrown in every direction, and produced a peculiar whizzing sound in the air, which, with the clattering occasioned by their striking one another, and the continual subterraneous thunder, excited an intense feeling of terror. In the following night twenty-five columns of fire of different colour were seen, issuing from as many abysses By degrees they joined each other and formed three craters, of which the middle one is the largest. After about eighteen hours the eruption ceased, and nothing was seen except columns of smoke rising from the craters, particularly from the larger. In this state the convulsed tract remained up to the 22nd of August, when a large quantity of matter, mostly consisting of pieces of conglomerate and rounded stones, was thrown

out from several openings in the ground. Together with these, large volumes of water ran out of the craters, but did not rise to any height above their edges. This water was turbid and brackish, though less bitter than sea-water; it had a very disagreeable smell of sulphur. These eruptions continued for three or four days. The smoke, however, and the dull subterraneous noise lasted for some time longer, and both decreased gradually until they ceased. The matter brought from the bowels of the earth by this eruption, formed three moderate hills of irregular form. The sand and ashes which arose, mingled with the smoke, were carried by a gale to a considerable distance. It must, however, be observed, that this eruption was, after a lapse of more than a month, followed by another of a truly volcanic character, by which lava and other volcanic matter was ejected; but this last-mentioned eruption occurred at a distance of several miles from the place where the first had taken place.

43. When a country is convulsed by severe shocks of earthquake for any length of time, the inhabitants commonly begin to fear that an eruption will take place, and that a volcano will be formed in some place in their vicinity. This fear, however, is ill founded, for there is only one well-ascertained fact on record of earthquakes having terminated in the formation of a volcano. This event happened in 1759, in the State of Michoacan, one of the United States of Mexico, where a volcano, called Jorullo, which rises 5119 feet above the sea-level, and 1683 feet above the plain on which it stands, issued from the bowels of the earth. The plain on which the volcano rose, was, up to 1759, chiefly covered with sugar and indigo plantations, which were irrigated by the waters derived from two small rivers; the plain itself, however, is surrounded by basaltic rocks, the structure of which appears to indicate that this part of the country, at some remote period, had experienced more than once the effects of volcanic agency. In the month of June, 1759, a subterraneous noise was heard, which continued for fifty or sixty days, and was attended with frequent

earthquakes. At the beginning of September, all was quiet but in the night between the 28th to the 29th of September, a terrible subterraneous crash filled the inhabitants with such terror that they abandoned their houses, and sought refuge on some mountains bordering the plain A portion of the plain, covering an area of from twenty-two to thirty square miles, was then seen rising in the form of a bladder, and is at present called El Mal Paes, a name which frequently occurs in Mexico, and is given to such tracts as are rendered sterile by the effect of volcanic action The border of this raised tract is still distinctly marked by the fractured rocks which constitute it Near this border the raised ground is not quite forty feet above the plain, but in advancing to the centre and the base of the volcano, it rises gradually to more than five hundred and twenty feet Over the surface of the raised ground, some thousands of small conical eminences are dispersed Their summits are only from seven to ten feet above their bases, and have openings on their most elevated points, from which smoke constantly issues, rising into the air from forty to sixty feet, in several of them a subterraneous noise is heard, which seems to indicate that there is a hot fluid not far below the surface Though the heat of the air produced by these vapours had, according to the statement of the natives, much diminished during the last fifteen years preceding the visit of Humboldt, that traveller found that the thermometer rose to 183° when placed over the fissures which discharged the watery vapour In a line traversing the raised ground from north-north-east to south-south-west stand six large hills, rising from 1500 to 1683 feet above the ancient level of the plain The most elevated of these hills is the volcano of Jorullo. It is still active, and has thrown out on its northern side an immense quantity of scorified and basaltic lava, which contains small fragments of primitive rocks. Up to the month of February, 1760, the eruptions of this volcano were very violent and frequent, but since that time they have become less powerful and more rare. During the first eruption the roofs of the houses in Queretaro,

though the distance between the two places is one hundred and thirty-five miles, were covered with ashes. Humboldt descended into the crater to the depth of one hundred and eighty feet below the outer edge, but he could not go lower on account of the dense hot vapours which ascended from its bottom According to his estimate this bottom is nearly one hundred and eighty feet below the point, which he reached in his descent

More who had observed the progress of this volcanic formation from some mountains not far distant, state that they saw flames issuing from the earth over a surface of more than four square miles, that fragments of red-hot rock were thrown up to great heights, and that through a thick cloud of ashes, which was illuminated by the volcanic fire, it appeared as if the softened crust of the earth was swelling, and resembled a sea in violent motion The two rivers, which watered this part of the plain, rushed into the fiery vents, and the decomposition of their waters contributed to increase the flames, which rose to such a height that they were visible in a town which stands on a large plain three thousand seven hundred and sixty feet above that on which the volcano rests The two rivers above mentioned are at present lost under the lava, but on the western side of the Mal Paes there are now found some hot springs, in which the thermometer rises to 105°

44 The most remarkable phenomenon produced by the concurrence of earthquakes and volcanic agency, is the emerging of new islands from the sea "They rise suddenly, and their appearance is attended with nearly all the phenomena accompanying eruptions, they exist for some time, and then they commonly disappear gradually It is a circumstance worthy to be noticed, that such islands make their appearance repeatedly on the same spot, and that such spots may be pointed out in each of the volcanic systems of Europe

In the volcanic system of the Azores, the spot where the volcanic islands appear is about a mile west of the western extremity of the island St. Miguel An island

has risen there above the sea at three different periods, in 1628, 1720, and 1811 It has been considered as a remarkable fact, that about ninety-one or ninety-two years have passed between the re-appearance of the island. Respecting the first phenomena which attended the first appearance of the island, nothing is known, but the second (1720) was preceded and attended by a very high column of smoke, and the ejection of ashes and pumice-stone Its declivities were very steep, as at a very short distance from its shores no ground was found with twenty fathoms Its elevation was estimated at about three hundred and fifty feet above the sea-level. After having preserved its size for about two years, it disappeared by degrees

In 1811 the formation of the island was preceded by severe and numerous shocks on the north-western side of St Miguel Before these shocks ceased, on the 13th of June, a column of smoke rose out of the sea, within which from time to time large masses of black cinders, sand and ashes were observed rising, accompanied by frequent flashes of lightning and a noise like thunder, which was compared to a continual firing of guns and muskets In a short time a black body was perceived to form the base of the column, and was soon recognised as the upper border of a crater-formed rock, rising from the sea, which, on the fourth day after the beginning of the phenomenon, formed a coherent mass This mass increased by the addition of new matter to the 4th of July, when it had attained its largest dimensions. The eruptions of matter then ceased, and a landing could be effected on the shores of the island. The island had nearly the form of a circle, and was about a mile in circuit Its greatest elevation above the sea-level was estimated at about three hundred feet In the middle was a circular crater which, by an opening across the solid mass, communicated with the sea, from which water in a high state of ebullition was continually and rapidly flowing The declivities of the island towards the sea were very steep, and the sea round it deep, for at a distance of twelve or fifteen yards it was more than fifteen fathoms

deep Captain Tillard, who had witnessed its formation from the adjacent shores, called this island Sabrina, after the name of the vessel under his command. In the following month of October the island began to diminish in size Some months later only a reef was observed, which at high-water was covered by the sea. In February following a column of smoke of very little density was seen rising from the same spot for a short time In 1823 it was found that the sea at that spot was sixty fathoms deep, twice as deep as it had been before the appearance of the island

In the Icelandic volcanic system, the spot at which an island has risen from the sea is opposite Cape Reikianaes, at a distance of about five or six miles from the promontory Only one appearance of this island is on record It took place in 1783, shortly before a great eruption of the Skaptaa Yokul No detailed account has been published of this event

45 Up to a recent period it was unknown that such a spot existed also in the volcanic system of Southern Italy, as in none of the numerous records of history which we possess of the events that have taken place in the countries surrounding the Mediterranean during more than two thousand years, is any mention made of such an occurrence The greater was the surprise of all persons who take an interest in such extraordinary facts, when, in the summer of 1831, an island rose out of the sea, between the town of Sciacca, in Sicily, and the volcanic island of Pantellaria, in 37° 11′ N lat and 12° 44′ E long. As the phenomena which attended the appearance of this island were observed by some naturalists and several scientific men, we possess a much more detailed account of them than of those of any other of these strange products of the bottom of the sea; and, as they certainly are of a very extraordinary description, a short enumeration of them will probably be acceptable to the reader

We shall premise that, among the inhabitants of Malta, a tradition is current that a volcano existed on the same spot about the commencement of the last

century, and that in an old chart of the Mediterranean a shoal is laid down on nearly the same place, with only four fathoms water on it Before the period of the eruption, however, it is stated that the sea at this place was from one hundred to one hundred and twenty fathoms deep.

Before any appearance of a change was observed in the sea, the inhabitants of the town of Sciacca were alarmed by a number of very smart shocks, of which two might be called severe They occurred between the 28th of June and the 2nd of July An Italian vessel, passing on the 8th of July near the place where afterwards the island rose out of the sea, observed a great disturbance of the waters at that spot According to the account of the captain, a considerable space of the surface of the sea was seen rising to an elevation of from eighty to ninety feet above its level, the water appeared to bubble as if boiling, and the phenomenon was attended by a noise resembling thunder After this agitation had lasted about ten minutes, the watery mass sunk to the sea level, but after some time rose again These risings of the water were repeated at irregular intervals of ten, fifteen, and twenty minutes A thick cloud of smoke, which enveloped the whole horizon, issued from the raised mass of water The surface of the sea surrounding the raised mass was also considerably agitated, and a number of dead fish were floating about For several days the atmosphere surrounding the town of Sciacca was dim and foggy, so that it was impossible to observe what was going on at sea On the 12th of July, in the morning, people were surprised at finding on the surface of the sea in front of the town, a great quantity of small porous scoria, which had been carried there by a fresh breeze from the south-west. On the beach the accumulated scoria formed a layer several inches thick, and the fishermen found, at some distance from the shore, the surface of the sea so covered with scoria that they were compelled to push them out of the way with their oars At the same time a very unpleasant smell of sulphuric hydrogen gas incommoded the inhabitants of the town and the country near

it Dead fish, recently killed, were floating in all directions

On the following day the sky cleared up, and at Sciacca a tall column of smoke was observed issuing from the surface of the sea This smoke continued to rise without interruption and in a straight column, from time to time a noise was heard similar to distant thunder, and when it became dark, frequent flashes of fire appeared to issue from the column resembling sheet lightning in warm summer nights On the following days it was observed that a dark mass formed, as it were, the base to the column of smoke

On the 18th of July, Captain Swinburne, of H M ship Rapid, on his passage from Marsala to Malta, had a nearer view of what was passing He approached the spot towards night, stopped to examine it, and gives the following account "A high irregular column of white smoke rose from the sea I saw flashes of brilliant lightning mingled with the smoke, which was still distinctly visible by the light of the moon In a few minutes the column became darker and larger, almost immediately afterwards, several successive eruptions of lurid fire rose up amongst the smoke, they subsided, and the column became gradually white again During the night the changes from white to black, with flashes, and the eruptions of fire continued at irregular intervals varying from half an hour to an hour At five o'clock in the morning, when the smoke had for a moment cleared away at the base, I saw a small hillock of a dark colour a few feet above the sea This was soon hidden again, and was only visible through the smoke at the intervals between the more violent eruptions

"The volcano was in a constant state of activity, and appeared to be discharging dust and stones, with vast columns of steam At half-past seven the rushing noise of the eruption was heard At nine o'clock, being distant from it about two miles, I hove to, and went in a boat to sound round and examine it. We rowed towards it, keeping on the weather side and sounding, but got no bottom till within twenty yards on the

western side, where I had eighteen fathoms soft bottom, this was the only sounding obtained except from the brig, one mile true north from the centre of the island, where the depth was one hundred and thirty fathoms soft dark brown mud The crater (for it was evident such was its form) seemed to be composed of fine cinders and mud of a dark brown colour Within it was to be seen, in the intervals between the eruptions, a mixture of muddy water, steam, and cinders, dashing up and down, and occasionally running into the sea over the edge of the crater, which I found on rowing round to be broken down to the level of the sea on the west-south-west side, for the space of ten or twelve yards Here I obtained a better view of the interior, which appeared to be filled with muddy water violently agitated, from which showers of hot stones or cinders were constantly shooting up a few yards, and falling into it again, but the great quantity of steam that constantly rose from it prevented my seeing the whole crater

"A considerable stream of muddy water flowed outward through the opening, and, mingling with that of the sea, caused a discoloration which had been observed before in various places I could not approach near enough to observe its temperature, but that of the sea within ten or twelve yards of it was only one degree higher than the average, and to the leeward of the island in the direction of the current (which ran to the eastward) no difference could be perceived, even where the water was most discoloured, however, as a mirage played above its source, it was probably hot there. The dark objects on the surface of the sea proved to be patches of small floating cinders The island or crater appeared to be seventy or eighty yards in its external diameter, and the lip as thin as it could be consistent with its height, which might be twenty feet above the sea in the highest, and six in the lowest part, leaving the rest for the diameter of the arch within These details could only be observed in the intervals between the great eruptions, some of which I witnessed from the boat. No words can describe their sublime grandeur.

Their progress was generally as follows after the volcano had emitted for some time its usual quantities of white steam, suddenly the whole aperture was filled with an enormous mass of hot cinders and dust rushing upward, to the height of some hundred feet, with a loud roaring noise, then falling into the sea on all sides with a still louder noise, arising in part perhaps from the formation of prodigious quantities of steam, which instantly took place. This steam was at first of a brown colour, having embodied a great deal of the dust, as it rose it gradually recovered its pure white colour, depositing the dust in the shape of a shower of muddy rain. While this was being accomplished, renewed eruptions of hot cinders and dust were quickly succeeding each other, while forked lightning, accompanied by rattling thunder, darted about in all directions within the column, now darkened with dust and greatly increased in volume, and distorted by sudden gusts and whirlwinds. The latter were most frequent on the lee side, where they often made imperfect water-spouts of curious shapes On one occasion some steam reached the boat, it smelt a little of sulphur, and the mud it left became a gritty sparkling dark-brown powder when dry None of the stones or cinders thrown out appeared to be more than half a foot in diameter, and most of them much smaller"

Another of H M ships, the Philomel, Captain Smith, was there on the 22nd of July He found the north-west part the highest, being about eighty feet above the level of the sea, and becoming lower towards the southern extremity The south-east side was broken down even with the water, which kept rushing into the crater with great noise, whence rose in turn an immense volume of white vapour, curling and spreading to an extraordinary height, intermixed in rapid succession with magnificent eruptions of cinders and lava thrown to the height of from four and five hundred to a thousand feet, forking and branching out as they ascended, and then pouring down with a noise like thunder, making the water a sheet of foam to a considerable distance around

it. During the night the eruptions were not remarkable for a very great quantity of fire, though a constant shooting of small columns was visible, with occasional flashes of sheet lightning, when near to it to leeward, the sulphur nearly suffocated the crews of the boats. The island appeared to be composed almost entirely of cinders with a sprinkling of lava, of an oblong shape, about three quarters of a mile in circumference, and, as was ascertained from the soundings, it had a very small base

The next eye-witness was a German naturalist, Hoffmann, who was on the spot two days later He estimated the diameter of the crater at about six hundred feet, and states that the ring of matter which enclosed it was continually increasing in height and width by the addition of what was thrown out from the crater He also distinguished two different states of action, one of comparative repose and the other of increased energy During the first the crater emitted continually, and with great velocity, immense volumes of vapour, white as snow, no kind of noise attended them Rushing across each other and whirling upwards in large convolutions, these masses of vapour formed a column, which, according to his estimate, rose to about two thousand feet above its base, and afforded a most splendid and magnificent sight when shone upon by the sun From time to time eruptions of cinders, distinguished by their black colour, were seen shooting across this column, and disturbing the large convolutions of vapours in their regular ascent The state of increased activity was indicated by a black column, of awful aspect, rising immediately below and at the side of the white one, to an elevation of about six hundred feet, or even more, at its upper extremity it expanded so as to take the shape of a wheat sheaf. Within this black column large masses of sand, ashes, and stones were seen moving up and down Numbers of these masses were thrown out of the column and fell down Every stone, which by the impulse it had received rose higher than the great masses, left behind it in the air a train of black sand. In this way ray-formed groups were formed,

similar to the twigs of a cypress tree, or the tufts of a rocket flower, of dark colour, they afforded an extremely beautiful appearance. During the whole time of this paroxysm the sea was hissing, doubtless from the great number of masses of sand and stone which were falling into it, evidently heated to a great degree, while clouds of steam then rose from the surface of the water and enveloped the island, so that it could not be seen any longer. Meanwhile a rattling and crashing was heard, occasioned by the stony masses meeting and clashing against one another, and also a continual rustling like that of a hailstorm or a very heavy shower of rain. No flames were observed to issue from the crater, nor was any light perceived, but at the periods of the most intense energy a great number of lurid flashes of lightning were seen shooting in every direction through the dark column, and each of them was followed by a loud and protracted thunder, which, when heard at a distance, appeared as one uniform and rumbling noise. These awful eruptions continued sometimes only for eight or ten minutes, but sometimes they were prolonged for the space of almost an hour. When they ceased they were followed by a state of repose, in which the above-mentioned column of white vapour only continued to issue from the crater.

Captain Senhouse effected a landing on the island on the 3rd of August, took possession of it, and called it Graham Island. He found the form of the crater to approach that of a perfect circle, and to be complete along its whole circumference, excepting for about two hundred and fifty yards on the south-east side, which was broken and low, not apparently above three feet high. The height of the highest part he found by a rough computation to have been about one hundred and eighty feet. The outer diameter he estimated to be almost six hundred and forty yards, and the inner about four hundred. The whole circuit of the island he conceived to be from a mile and a quarter to a mile and one-third. He collected a quantity of the materials of which the island is composed. They were all very hot when gathered. They were compact and heavy, and

the whole surface of the island dense and perfectly hard under foot. No variety of stones was found, nor any lava, nor did he observe any jets or streams of lava

In the beginning of the month of August, the eruptions began to be less active, and then they decreased gradually until they ceased on the 12th of August Persons who visited it after that date estimated the height of the island at about two hundred feet, but soon afterwards the waves of the sea began to re-acquire their ancient dominion they tore off by degrees one piece after the other, and in the month of December the whole island had disappeared Afterwards it was ascertained that not even a trace of a shoal had remained behind

46 In all the instances hitherto adduced, the islands which had risen from the bottom of the sea vanished after a short existence But there is one instance on record in which an island thus formed has existed for a great length of time, and probably continues to exist, as no information has reached us of its disappearance This island made its appearance in 1796, in that chain of volcanic islands which connects the Ancient Continent with the New World, extending in a curved line from the Peninsula of Kamtschatka to that of Aliaska, and which is called the Aleutes The new volcanic island lies near a larger one called Umnak A violent gale had been raging for several days, when, on the 8th of May, after the weather had cleared up, a large column of smoke was seen rising from the surface of the sea, and on the same day the island was observed In the following night flames and stones were seen to issue from the new formation, and some of the stones were flung so far that they reached the island of Umnak. At the same time the last-mentioned island was convulsed by a severe shock of an earthquake. All these phenomena, with the exception of the earthquake, continued for a long time, and increased the volcanic island to a considerable size. By degrees, however, the flames decreased, and at last ceased entirely; but smoke was seen continually rising from the newly formed masses. In 1804 the

eruption had ceased so far that some persons ventured to land The sea near the shores was still very hot, and the soil of the island at many places so heated that it was impossible to walk The island continued to increase even after that period, at least up to 1806 In that year it was visited by some scientific men, whom it took six hours to sail round the island, and five hours were required to walk from the beach to its summit, which shows its great extent, and the great elevation of its summit. The northern side was still in a state of convulsion, and here a stream of lava was found to extend from the summit to the sea This evidently shows that this island is different from those which rose from the sea near the island of St Miguel, and in the vicinity of Sicily, where it is stated no lava was thrown up The island near Unnak is therefore to be considered rather as a true volcano of new formation, like Jorullo in Mexico

47 Though we have no certain record that an island which has risen from the bottom of the sea in the above described manner has preserved its existence, we can hardly doubt the fact when we find that in nearly every group of islands of volcanic origin, one or more small ones are found which in form exactly resemble the islands which have risen from the sea These islands have always the shape of a horse-shoe, or of a half-moon, and in most cases enclose basins, forming excellent harbours for small vessels, within which they can lie protected against all winds, but the enclosed area is rarely deep enough to afford anchorage for larger vessels The ring-like ridge of high land which surrounds the basin rises from its shores with a very steep, almost perpendicular acclivity, so that hardly any path can be found by which the crest of the ridge may be attained from the bay. The declivity towards the open sea is also rather steep, but less so than that directed towards the basin, and on this side the summit may be ascended, though always with difficulty The sea surrounding such islands, in most cases if not in all, is of considerable depth. As these islands occur only in those groups which are of volcanic origin, and always have the form

of a crater, except that at one place the circular ridge of land surrounding the basin is broken down so as to constitute a strait, by which the basin communicates with the sea, it is evident that they owe their origin to a process similar to that of a volcanic eruption It is, however, commonly found that lava is one of the components of the ridge, which has not been observed in those islands which have only had a temporary existence

48 One of the islands of this description has attracted the especial attention of philosophers, on account of the islands which have been raised from the bottom within its basin, and have not again disappeared like those already described This is the island of Santorin, one of the Greek islands called the Cyclades This island has the shape of a horse-shoe, and encloses nearly two-thirds of an almost circular basin In the opening which constitutes the remainder of the circle are situated two other islands, called Therasia and Aspronesi, which by three narrow straits are separated from each other, and from Santorin The three islands together form a complete ring, only broken at three places, and these openings are, as observed before, of small extent. At the bottom of the basin thus included, volcanic force has been active at several times within the period of which we have historical records In the year 184, or according to others, in 197, before our æra, a new island appeared within the basin, which was called Hiera by the ancients This island still exists, and is sometimes called Hiera Nisos, but is better known under the name of Palaia Kameni Another island arose in the year 18, after Christ's birth, very near to Hiera This island, which was called Thia, is not to be found at present, but it is doubtful whether it has returned to the bottom or has been joined by other eruptions to Hiera, for, according to some accounts, Hiera has received considerable addition to its size by some eruptions which took place in 726 and 1427 Another island arose nearly in the middle of the basin in 1573. It is called Mikra Kameni, and forms, according to the most recent accounts, a perfect cone, about a hundred feet high, with a crater on

its summit Much larger was the island formed there in 1707, and which bears the name of Nea Kameni. Its appearance was immediately preceded by a severe earthquake From a place where no ground was found with eighty or a hundred fathoms a rock suddenly emerged, which soon increased in size by accumulation. This happened on the 23rd of May, and on the 15th of June the island was nearly two miles in circumference, and from twenty to thirty feet high On the 16th of July eighteen rocks are stated to have emerged from the surface of the sea, near the new island, whilst a very loud subterraneous noise was heard Two days later a column of smoke issued at these places, to which, the day after, flames were added, and these phenomena of the process were continually increasing in intensity. During the night the island resembled a number of furnaces, from which fire was shooting out All the rocks, which for some time were isolated, were at last connected by the quantity of new matter brought up from the bottom of the sea, and formed at length a conical mountain more than three hundred feet in elevation, from the crater of which vapours and stones for a considerable time were thrown out, and streams of lava descended As late as 1712 this island was still acquiring large additions to its size in this way.

VOLCANOES.

1 By earthquakes the bowels of the globe are relieved from the pressure produced by the elastic fluids confined in its interior This pressure may be the effect of an increase of their mass, or of their elastic forces becoming more active The solid and liquid matter which is occasionally ejected appears rather to have been collected during the passage of the elastic fluids through the earth's crust, than to proceed from the central regions of the globe. Besides, those chasms which are opened by earthquakes, and from which elastic vapours escape and solid matter is sometimes thrown up, are only temporary, and of very short duration. In most cases it is hardly possible to convince one's self that such chasms have really existed, as soon as the earthquake has ceased.

But there exists a much more permanent and more complete communication between the bowels of the globe and its surface, by which not only immense volumes of elastic vapours find their way to our atmosphere, but solid matter of a peculiar character is brought to the surface, which has evidently originated below the solid crust of the earth. This communication is formed by *volcanoes*, which are openings in the earth's surface, and from them the elastic vapours and melted matter in the highest state of ignition escape from the interior of the globe We may, therefore, safely assume that volcanoes are the orifices of long conduits or pipes, which traverse the earth's crust through all its thickness, and are, with reason, compared to chimneys We are totally unacquainted with the structure of these volcanic chimneys, and all we know of this great process of Nature is confined to our knowledge of the openings of the chimneys, and of the manner in which the subterraneous force acts and the subterraneous matter is ejected

2 The number of volcanoes is very great, but not in

all of them is the communication between the interior of the earth and its surface equally complete. In this respect we must distinguish four classes of volcanoes A great number of them are *completely extinct*, or, in other words, their communication with the interior has ceased to exist long ago Many others are *semi-extinct*. In these volcanoes the communication between the interior of the globe and its surface is not entirely interrupted, but is limited to the discharge of vapours and gases which escape through narrow rents No actual solid matter is brought up by them, but various solid bodies, soluble in vapours and gases, are deposited by these elastic fluids, when, by their contact with the atmosphere and their condensation by cold, they form chemical combinations different from those in which they previously existed The solid matter brought to the earth s surface in this manner is, however, but small The third class is formed by the *intermittingly active volcanoes*. When in a state of repose these volcanoes resemble in their operations the semi-volcanoes in every respect, but at intervals of shorter or longer duration they acquire for a short time an increased activity, by which they are enabled to eject great masses of melted matter, which overflow the countries contiguous to them Such paroxysms of volcanic agency are called *eruptions* The fourth class of volcanoes comprise those which are *permanently active*, discharging from their orifices melted matter without intermission

It happens, however, sometimes, though not frequently, that at some particular spot the surface of the earth opens and discharges large quantities of volcanic matter without forming a volcano Such chasms, after having remained open for some time, are blocked up and do not open again. Such may be called *irregular volcanic eruptions*

3 To whichever of the four classes above-mentioned a volcano may belong, the orifice of the volcanic chimney is always surrounded by a deposit of matter, which takes the form of a hill or even of a mountain These volcanic mounds are distinguished from other hills and

mountains by a peculiar shape. The upper part of them is always [illegible], and on its summit, or near it, a depression occurs, [illegible] at the orifice of the volcanic chimney. The conical hill by which the volcano is crowned is not accidental, but is the effect of its own operations. A quantity of the matter which is ejected by the subterraneous forces from the depression in the middle of the summit, is lodged on all sides round about the opening, and there it is accumulated by degrees, so as to form, in the lapse of time, a smaller or larger hill, according to the quantity of matter which has issued from the opening.

4. Volcanoes are found in different situations. Many occur in plains but little elevated above the level of the sea, and at considerable distances from other mountains, so as to stand quite isolated. It is supposed, when so situated, that the volcanic mountain has risen from the bottom of the sea by the effects of the volcanic agency, and that the plain which surrounds it has been raised above the sea-level by the gradual accumulation of the matter ejected from the orifice of the mountain. This supposition is, in most cases, supported by the fact, that the upper layer of the soil of such plains is almost entirely composed of materials derived from the decomposition of volcanic matter, and that it rests on a thick stratum of such matter.

Many volcanoes are situated in the midst of mountain-ranges or contiguous to them. In either situation they are placed in a line, but at distances from each other, varying greatly in extent. Such lines extend parallel to the longitudinal direction of the mountain-masses. An exception to this arrangement, however, occurs on the table-land of Mexico. On this table-land, which is supported by mountain-masses rising to between 5000 and 7000 feet above the sea-level, the volcanoes are disposed in a line which runs transverse to the elevated plain.

5. In looking at the exterior shape of an isolated volcano, it is at first sight evident that it consists of two different parts, the base and the cone.

When a volcano is situated in a plain, its *base* forms, in most cases, a circular elevation, which is frequently tolerably regular, but in some instances assumes a lengthened form. Its surface is very uneven, but not much broken, and its general slope mostly rather gentle, so that it may be ascended without fatigue. Its soil is a firm mass, and when examined is found to be composed of volcanic substances. Its upper layer consists of cinders, ashes, and rapilli, which, by themselves, would form a loose mass, but as a portion of these materials have been decomposed by the effect of the atmosphere and its moisture, and thus have been converted into a mouldy earth, the whole has been cemented together by this new product, and acquires a considerable degree of firmness. Such a soil is of great fertility. At some places streaks of lava are found, left there by the streams which at former times have run down the declivity to the base. A few of these layers of lava are destitute of vegetation. This is the case when the lava has but recently left the mountain, or is of so hard a texture that its surface has not been decomposed by the atmospheric moisture, though exposed to it for a century or longer. These tracts of lava, where they can be brought into cultivation, are very fruitful, and as every kind of fruit especially thrives well, they are covered with extensive orchards and vineyards. Even when such a layer of lava has not yet been decomposed on its surface, the industrious husbandman tries to turn it to account provided its thickness be not too great, that is, if it does not exceed twelve or fifteen feet. In such a case people make holes in the lava of a depth sufficient to reach at the lower end the earthy soil over which the lava has flowed. These holes, which vary from one to two feet in diameter, are filled up with earthy matter and mould, and then vines or orange-trees are planted in them. The best vineyards on the base of Mount Vesuvius are planted in this way, and the same is done on the island of St Miguel with the orange-plantations. It is easy to be conceived that such an operation must be very expensive on account of the labour required to pierce such

a hard mass to such a depth, but the produce of such plantations is so superior to others in abundance, and the flavour of the fruits and grapes, so excellent, that in a few years the expenses are covered and the labour compensated. To the superior fertility of the soil at the base of the volcanoes, and over the adjacent country, it is owing that these spots are cultivated in preference to all others. This is especially the case in Central America and some other parts of the New Continent, where almost all the populous towns are built near volcanoes, in despite of the danger to which they are exposed when an eruption takes place. When the ascent of the base is too steep to admit of cultivation, as the upper portion of the base of Mount Etna, in Sicily, it is overgrown with fine large forest-trees. In sinking wells on the base of a volcano, it is found to be composed of a large number of layers of lava, sometimes as many as twenty and more. They are separated from each other by comparatively thin layers of earth, which evidently proves that a considerable time has elapsed between the eruptions which have produced the streams of lava, as the surface of the older lava has undergone decomposition before the issue of the more recent one. In penetrating still deeper into the interior of the mass, it is ascertained that below the lavas that kind of rock is found which is called trachyte, and which our modern naturalists are inclined to consider likewise as a volcanic production.

6. The *cone*, which has obtained its name from its shape, is nearly always of a regular form, which is owing to the materials of which it is composed. Its whole surface is covered by a deep layer formed by the accumulation of rather small pieces of volcanic matter, of scoria, ashes, and sand, and as in this aggregate no kind of matter enters which could cement them into a solid and firm mass, they lie loosely upon each other, and give way even to a moderate pressure. Persons ascending the cone of a volcano are soon aware that the soil under foot slides down, and that they lose frequently by one step what they have gained by many. Under such circumstances it would in most cases be impossible to attain

the summit of the cone of a volcano, especially as it commonly rises with an acclivity of from 36° to 42°, if it were not that at a few places this moveable soil is covered with a narrow strip of lava, which has run down the cone, and affords a firm footing. It is supposed that this loose volcanic matter forms a layer of many feet in depth, but it is certain that the whole mass of the cone is not composed of similar materials, and that the loose matter rests on the same kind of rock (trachyte) which constitutes the principal body of the base. For when by an eruption of the volcano the loose volcanic matter filling the crater has been carried away so as to lay bare the rocks which constitute the body of the volcano, it is found that it is trachyte. It is hardly necessary to add, that the surface of the whole cone is entirely destitute of vegetation, and by its black colour affords a contrast with the well cultivated and wooded base, which forcibly strikes the mind of the observer.

The proportion between the height of the base and that of the cone is not the same in all volcanoes, but differs materially. The least difference appears to be that observed in Mount Vesuvius, whose cone constitutes nearly one-third of the elevation of the mountain. In the Peak of Teneriffe, the elevation of the cone falls short of one twenty-second part of the whole height of the volcano. This difference is not accidental; it is the effect of the difference of the part whence the eruptions of the volcano occur. When the eruptions are commonly or uniformly effected from the crater enclosed by the cone, the loose volcanic substances ejected from the crater are shed over the cone, and thus its height is gradually increased. This is the case with Mount Vesuvius. But when, on the other hand, the eruptions do not break out from the crater at the summit, but from an opening at the side of the volcano, as appears to be always the case with the Peak of Teneriffe, the volcanic matter is dispersed over the base, and the cone is not increased by accumulation.

7. The cone encloses the *crater* on all sides; for the

crater is the deep depression which is found on the summit of the cone, and sometimes descends a thousand feet below the highest part of its rim. In most cases a full view of the crater is obtained as soon as the summit of the cone is reached, as there is no level ground between the outer and inner declivity of the cone. Where the upper edge of the outer declivity terminates, the descent into the crater begins. In a few volcanoes, however, a remarkable difference in the structure of this part of the mountain has been observed Humboldt found that the summit of the cone of Mount Cotopaxi, in the Andes, terminated in a nearly perpendicular wall of rocks, from twenty to thirty feet in height, which runs round the crater and prevents any descent into it. On this account the crater of that volcano has never been visited The same traveller found a similar mural enclosure, but of much less elevation, surrounding the crater of the Peak of Teneriffe, but as this wall is broken down at one place, travellers obtain an easy access by this opening to the bottom of the crater

The crater itself has the form of a funnel It consists of regularly descending sides, which terminate in a plain at their lower end, where they approach each other The descent to this bottom is as rapid as the ascent of the cone, which is easily accounted for, as the same loose matter covers the interior declivity of the cone which lies on its outer surface. The bottom in which these declivities terminate is commonly of a circular shape, but in some volcanoes it has an elliptical form This is, for instance, the case with the bottom of the crater of the Peak of Teneriffe which in its greatest length measures about three hundred feet, and in its width only about two hundred This bottom does not undergo any change in the extinct, nor in the semi-extinct, volcanoes, but it is subject to great and frequent changes in the intermittingly active and in the permanently active volcanoes These changes are greatest in the intermittent volcanoes, as this bottom is the place at which the temporary opening is effected, by which the interior of the globe is brought into immediate commu-

nication with our atmosphere, and from which frequently the melted matter issues, ejected by the elastic forces. But it is not only during the eruptions that the bottom of the crater is changed Even in the intervals between two eruptions, when the volcanic forces are considered as being inactive, the bottom undergoes various changes, as will be noticed hereafter

8 The *extinct* volcanoes are very numerous. Numbers of them are met with even in countries where at present no traces are observed which could lead us to suppose the existence of any volcanic power, as in the south of France, and in some counties near the banks of the Rhine They are not, however, easily recognised at first view, as the features which distinguish them from other hills do not present themselves in a striking manner when they are overgrown with woods or bushes, or covered with crops But on a closer inspection their conical shape and a depression on the summit betrays their origin In many cases it is found that the bottom of the crater is partly occupied by one or two small lakes, and in some it forms one large lake When this is not the case, the bottom, as well as the acclivities which surround it, is almost always overgrown with bushes and woods, which are much resorted to by wild animals In most cases some streams of old and decomposed lava are discovered in their vicinity, and by digging to a small depth, volcanic matter is found in such abundance as to leave no doubt respecting their origin In a few of these volcanoes a very feeble index occurs of their not being entirely extinct, at some place in the bottom of the crater an irrespirable gas, commonly carbonic acid, is emitted

In some volcanic countries also there are found a great number of extinct volcanoes, as in the vicinity of the town of Naples, where two remarkable ones are situated close to each other, so that they may be seen and examined at the same time The larger one has its bottom filled up by a lake of considerable extent, the Lake of Agnano, and on its eastern bank is the Grotto del Cane, from the bottom of which carbonic acid is emitted On the other

side of the lake is a very beautiful extinct volcano, of smaller dimensions, which bears the name of Gli Astruni. Though it is known that for more than two thousand years the volcanic power has not been active in its crater, this volcano still preserves its conical shape, and every other sign of volcanic origin, in its greatest perfection The rim of the crater may be about six miles in circumference, and in the small plain which constitutes the bottom are two small lakes. Its sides are almost entirely overgrown with bushes, interspersed here and there with large walnut and chesnut-trees. As this crater has been converted into a royal deer-park, it is surrounded by a wall

It is frequently asked, whether or not it is possible or probable that volcanoes, which at present are in such a state, can again be re-animated by volcanic agency, and re-assume their former activity? Though there is no great probability that such an event will take place, its possibility cannot be denied, when it is considered that Mount Vesuvius, during the period of which records are preserved, has been twice considered as an extinct volcano Before the first known eruption of this mountain, which occurred in 79 of our era, several ancient authors noticed the state in which it then existed They all agree in stating that it must have been active at a very remote period, but no eruption was then recorded or known Strabo gives a description of it, which characterises it as an extinct volcano Again between 1500 and 1631 it presented a similar aspect A scientific Italian, who visited the volcano a few years before its eruption of 1631, gives the following description of its then state "The crater was five miles in circumference, its sides were overgrown with brushwood, and at the bottom was a plain on which cattle grazed. In the woods boars frequently harboured In the midst of the plain within the crater was a narrow passage, through which by a winding path you could descend about a mile among rocks and stones until you came to another more spacious plain, covered with ashes, in which were three little pools"

9 Extinct volcanoes commonly offer little or nothing that can strike the imagination of the observer, but it is quite otherwise with the *semi-extinct* volcanoes These are called by the inhabitants of Italy *solfataras*, which term has also been adopted by scientific writers. In the West Indies, where several of them occur, they go by the name of *soufrières* Both these terms indicate that such places are natural deposits of sulphur

On obtaining sight of the crater of a semi-extinct volcano for the first time, the observer is astonished at the total change of nature Everything is different from what he has been accustomed to see from his youth The white colour which is spread over the whole space before him makes the strongest impression It greatly resembles chalk, but it fills the mind directly with the idea of desolation, as nowhere can the least sign of vegetation be perceived On account of this extraordinary white colour, the solfatara near Puzzuoli, in the Bay of Naples, was called by the ancient writers *campi leucogaei* When the first impression which this uncommon aspect produces has somewhat abated, the observer perceives that, from several places in the bottom as well as from the sides of the crater thin streams of smoke escape, which in many cases unite so as to constitute a considerable column In advancing towards the bottom of the crater, the traveller is rather alarmed by the hollow sound, which is heard when he stamps the ground with his feet, or throws down a stone It appears to him as if he was walking over an arched vault, and the natural inference is, that there must exist a cavern at no great distance under ground In approaching the places where smoke is seen issuing from the ground, he finds that this is effected by means of numerous cracks, whose edges are covered with white, yellow, orange, and brown incrustations, which, by the numerous shades their colours assume, please the eye and agreeably engage the imagination Sometimes these incrustations cover large tracts in the most striking manner, and the effect is heightened by the white or grey smoke which rises between them The pieces of rock with

which the surface is strewed have usually a very rough surface, and they sometimes assume very fantastic shapes, some of them are split, and others are covered with protuberances not unlike large teeth When the visitor passes through the streams of vapour escaping from the cracks, he soon finds that they are of different natures Through many he may pass without feeling his respiration in the least affected, whilst others produce violent coughing, and sometimes seem to threaten him with suffocation These vapours are called in Italy *fumarole*

10 Of such a character are the phenomena presented by the semi-extinct volcanoes Natural philosophers have attempted to account for them, and, assisted by the progress of modern chemistry, they have succeeded in doing so in most cases in a satisfactory way

It has been ascertained that what at first sight appears to be smoke, is, in most cases, nothing but steam or aqueous vapour • This fact had already been inferred from the circumstance that persons, in passing through a column of such smoke, do not feel their respiration affected, nor do they perceive any peculiar kind of taste or smell, and it is confirmed when a knife or any cold body is exposed to the vapour, for the vapours, in touching such a body, are instantaneously condensed, and form drops on its surface consisting of pure water devoid of any peculiar taste The water obtained from such vapours may be used for drinking, and is used so at some places, as on the island of Pantellaria, which lies in the Mediterranean, north-west of Malta This island is of volcanic origin, and no springs are found there, it would be uninhabitable on that account were it not for some large streams of vapour, which ascend without interruption from the most elevated portion of the highest hill of the island These vapours are condensed by the inhabitants, who place bushes over the spots whence the vapours rise Thus they obtain a sufficient supply of sweet water for their own use and their herds of goats Such hot aqueous vapours, when passing over coloured bodies, have the power of whitening them, and they thus act

on the lava of which the bottom and the sides of the solfataras are composed Hence the white colour is derived which is spread over the whole surface of the crater, and strikes the observer so forcibly Several facts have been observed which support this explanation. Sometimes white spots are observed in streams of lava which have elsewhere preserved their natural black colour When the places where such white spots occur are more closely examined, it is always discovered that hot vapours protrude through the layer of lava Again, when large blocks of lava which have been bleached by the vapours are broken to pieces, it is found that at some distance from the surface the lava is less bleached, and in the middle it is quite black

11 Many of the streams of vapour issuing from the craters of semi-extinct volcanoes contain a smaller or larger proportion of hydro-sulphuric acid The presence of this gas manifests itself instantaneously by the manner in which the organs of respiration are affected When the hydro-sulphuric gas constitutes a considerable proportion of the vapour, it affects the lungs so forcibly that persons are compelled to remove promptly for fear of being suffocated Hydro-sulphuric gas is decomposed in the atmosphere into its bases hydrogen and sulphur, at a very low temperature This takes place with that gas which rises mixed with vapour from the crater of the semi-extinct volcanoes The hydrogen combines with the oxygen of the atmosphere and forms water The sulphur, of course, is dropped, and either crystallizes alone, or forms salts by combining with other bases By the crystallization of the sulphur the yellow incrustations are formed with which the rents of the crater are invested, and which assume different shades according to the lesser or greater state of purity of the mineral It happens sometimes that large masses of beautifully crystallized sulphur are met with In this way, the semi-extinct and also the intermittent volcanoes produce large quantities of sulphur, which is also occasionally turned to account by collecting and purifying the mineral, it is even supposed that when sulphur occurs in places where

no volcanoes exist, it nevertheless owes its origin to a similar process

When sulphur combines with other bases it yields different products Combining with lava containing a large proportion of clay, it forms alum The largest portion of this valuable mineral which is brought to market is extracted from the craters of extinct or semi-extinct volcanoes When the sulphur combines with lime, which also constitutes an ingredient of many volcanic productions, gypsum is formed In many semi-extinct volcanoes sulphur is found combined with arsenic These combinations mostly occur in the proportions which constitute those two sulphurets of arsenic which are known by the names of *realgar*, or red sulphuret of arsenic, and *orpiment*, or yellow sulphuret of arsenic.

There is hardly a semi-extinct volcano in which sulphur is not found in a liquid state, as sulphuric acid. It sometimes covers large tracts of lava, and to the corrosive quality of this matter the rough surface of many of the rocks, and their peculiarly fantastic shapes, are to be ascribed

12 Hydro-chloric acid is also found frequently, though not in all volcanoes, combined with aqueous vapours. When such is the case, the vapours form small convolutions, in rising from the cracks, of a snow-white colour. When a person enters such a current, his organs of respiration are so excited as to produce a violent coughing. Several substances are formed by combination with this acid The most remarkable is sal ammoniac, which is found in nearly all volcanoes, and in some of them in such quantities as to afford an article of trade This substance appears nowhere to be so abundant as in the volcanoes of Chinese Turkistan, where a whole province pays the taxes imposed by government by a supply of this valuable article. Another combination formed by the chlorine in volcanoes, is chloride of sodium, or common salt Large layers of it occur in some extinct volcanoes; and it is also sometimes thrown up in large lumps by intermittent volcanoes during their eruptions This was done by Mount Vesuvius in 1822 and in 1832, and has

also occurred during an eruption of Mount Hecla, in Iceland Several observers have occasionally found rents of volcanoes covered with a crust of common salt to a thickness of three inches Chlorine of iron is also frequently met with in volcanoes, and as this matter liquefies in the air, the internal sides of the crater are sometimes wonderfully adorned by the numerous shades of yellowish brown and red brown which this chlorine imparts Chlorine of copper appears also to occur sometimes among the products of the semi-extinct and intermittent volcanoes It is supposed that the beautiful green colour which is assumed by several salts adhering to the cracks of the volcanoes, is imparted to them by the chloride of copper Salts of this colour are much sought for by travellers on account of their beauty, and specimens of it are found in nearly all mineralogical collections

Besides the minerals just now enumerated, there are also found in semi-extinct volcanoes boracic acid and selenium These substances are frequent, particularly in the crater of the island of Volcano, one of the Lipari islands The boracic acid there covers large tracts of rocks with small scaly brilliant crystals, white as snow, and the selenium is there found combined with sulphur, to which substance it imparts a deep orange colour, which greatly increases the beauty of such incrustations

13 All the semi-extinct volcanoes do not exhibit an equal degree of activity Where the volcanic activity is still powerful, the crater is almost entirely filled up with stinking vapours and noisome smoke, its sides and bottom being covered with incrustations of sulphur and other deposits of different colours When to this we add, that no traces of vegetation are anywhere perceptible, and that no animal of any description is to be met with in its precincts, it is easy to comprehend that the impression the sight which such a spot makes on the beholder must be dismal in the extreme The ancients were so struck at the sight of the Solfatara of Puzzuoli, that they considered themselves as having arrived at the gates of the infernal regions, and

thence called that semi-extinct volcano *Forum Volcani.* It is at present, however, considered as a very insignificant one when compared with others with which we have became acquainted, especially with that on the island of Volcano. The crater of this solfatara is nearly 1400 feet in diameter, and its bottom about 400 feet below its rim This immense cavity is always filled with volumes of thick smoke, which escape with a loud noise from the fissures, and, in the lower portion of the crater, is so dense, that those who attempt to descend to the bottom expose themselves to the danger of being suffocated.

The largest of the semi-extinct volcanoes to be met with on the surface of the globe appear to be those which occur in the central countries of Asia, on the northern declivity of the Thian-shan mountains The Chinese geographers mention two of large dimensions there, both situated in the vicinity of the town of Urum-tsi One of them is stated to have a circumference of a hundred li, equal to thirty-five statute miles, and the circuit of the other amounts to ninety li, or thirty English miles How powerfully must the mind of the beholder be affected at the sight of such immense solfataras!

14 The *intermittent* volcanoes, during their state of repose, frequently so much resemble the solfataras, that the difference between them can only be perceived by very attentive observation According to the statements of Von Humboldt, the bottom of the intermittent volcanoes during their repose is covered with layers of scoria, which are very rough, sonorous, and shining, and small eminences occur, and swellings of the ground, raised, without doubt, by the operations of the elastic fluids; there are also small cones of very diminutive cinders and scoria, under which narrow openings are concealed. In the semi-extinct volcanoes, on the other hand, the bottom of the crater is strewed with large blocks of stony lava, which, in the lapse of time and by the action of the hot vapours, have been detached from its sides, and which have assumed a white colour In intermittent volcanoes the white colour is not general, and occurs only at a few places of small extent.

• The crater of the intermittent volcano sometimes remains in such a state for a length of time, until the volcanic powers acquire a more intense degree of activity. The changes the crater then undergoes by the operation are great and numerous, and continue to occur until an eruption takes place

15 The eruptions are commonly preceded by certain phenomena The most striking of them are the earthquakes, which are usually felt in the countries contiguous to the base of the volcano, when a great eruption is in course of preparation They are sometimes very severe, at other times but slight, and eruptions also occur which are not attended by earthquakes In some cases it has been observed that the earthquakes occur many months, or even years before the eruption takes place The most striking instances of this kind are the earthquakes which preceded the eruption of Mount Vesuvius in 79 of our æra For many centuries previous the volcano had been considered as extinct, as no eruption had been recorded, though during that period the country near it was inhabited by persons who paid considerable attention to the passing events, and recorded them with some degree of exactness It appears that the subterraneous force, long before the eruption took place, made some efforts to re-open the vent which had been shut up for so long a time Fifteen years previous very destructive earthquakes had been experienced in the country surrounding the base of the volcano The towns of Pompeii and Herculaneum were levelled to the ground, and Naples and Nocera, which lie at a greater distance from the volcano suffered considerably more distant places less Thus it was evident that the centre of the earthquake was within or under Mount Vesuvius. Considering this earthquake as being connected with the eruption which took place at a much later period, it would appear that the subterraneous forces, when they began to assume a greater degree of activity in the mountain had first to remove an immense obstacle before they could open the channel by which they were enabled to give vent to the elastic vapours penned up in the in-

terior, and to eject the accumulated matter. But at the time of the earthquake the inhabitants of these regions had not the least suspicion that this phenomenon was in any way connected with the mountain Therefore the inhabitants of Pompeii busied themselves with the rebuilding of their destroyed palaces and houses, and they had not completed their work when the town was buried under the volcanic matter thrown out by the first eruption of the volcano, for many of the disinterred buildings of Pompeii are still found in such a state as to make it evident that they were in the course of being built or repaired when they were covered with the ashes and scoria of the mountain The great earthquake of 63 was followed by several others of less force but they became more severe as the eruption drew nearer Some days before the eruption several severe shocks occurred, and the very night preceding the 23d of August such a powerful shock was experienced, that even at Misenum, a place which is more than thirty miles distant from the volcano every building was shaken to its very foundation Shortly after it had passed off, the summit of Mount Vesuvius was seen enveloped in that cloud of ashes which deposited its contents on the towns of Pompeii, Herculaneum, and their vicinity, and buried them under so thick a layer, that no traces of the most elevated buildings were perceptible

Not much less severe were the earthquakes which preceded the eruption of Mount Vesuvius in 1794, but they occurred a few days only before the eruption. It was then noticed that the surface of the country contiguous to the base of the volcano moved like a fluid from east to west, and even in the town of Naples the concussions were so strong that people passed the nights in the open places, for fear of being crushed by the downfall of the buildings The night previous to the eruption a very smart shock occurred It did not manifest itself by an undulatory motion, but by short and irregular shocks, which rent the walls of the strongest buildings, and threw everything into the utmost confusion. Immediately afterwards the reflection of the

melted matter in the crater was observed above the summit of the volcano That these earthquakes were intimately connected with the eruption, and, as it were, only phenomena attending the process going on in the bowels of the mountain, was evident from the manner in which they affected the contiguous country The nearer a place was situated to the base of the volcano, the more severely it was shaken The volcano was therefore the centre of the earthquake, from which it proceeded regularly on all sides, except where the bulky masses of the Apennines obstructed its progress Its force decreased also in proportion to the distance from the place where it originated This was proved by the fact that the towns of Nocera, Salerno, Capua, and Benevento suffered much less than Naples, which, however, was not so fearfully shaken as Portici and Torre del Greco

It is very probable that the degree of severity with which earthquakes act is determined by the actual state of the crater When the volcanic chimney is not much obstructed by thick masses of solid matter, or when these masses are so disposed as to yield easily to the subterraneous forces which strive to remove them, the shocks of the earthquakes are but slight Several eruptions have taken place which do not appear to have been attended by such consequences, as those of 1737, 1813, and 1822 When on the other hand the obstructions experienced in the narrow pipe are very great they can only be removed by the confined elastic vapours, after several repeated and powerful efforts In such a case the earthquakes must prove destructive

16. A less constant attendant of the eruptions is the retiring of the sea This has only been observed to precede some of the eruptions of Mount Vesuvius, and not those of other volcanoes At the first recorded eruption (79) it must have been very remarkable, to judge from the expressions in which it is mentioned by Pliny the younger In modern times it has been noticed twice. Sir William Hamilton observed it in 1775 The sea, according to his statement, rose as if it was agitated by

a violent gale, and then retired from the shores with great rapidity The last-mentioned circumstance appeared so striking, that many persons were inclined to suppose that the water of the sea had suddenly fallen into some rents in the base of the volcano, which carried it immediately to immensely large cavities in the interior of the mountain In these two cases the retiring of the sea occurred nearly simultaneously with the eruptions. In 1813 the sea retired many months before the mountain opened The eruption took place late in December, and in the months of May and June it was noticed that the sea retired several times, suddenly and with great swiftness, to a distance of from fifteen to twenty paces from the beach

It is not easy to explain this phenomenon According to the theory which prevailed in the last century respecting the origin and activity of volcanic agency, the accession of water was required to re-animate the subterraneous conflagration It was therefore supposed that the water of the sea found access to the bowels of the volcano by means of some submarine clefts The retiring of the sea appeared a natural consequence of this process, and was easily accounted for by such an absorption But this idea, as an explanation of the retiring of the sea, was speedily rejected It was observed that even if it is supposed that the whole mountain was hollow, and formed in its interior an immense cavity, the filling it up with water could not in the least affect the level of the sea in a perceptible manner, for, huge as the volcano is, its bulk is very insignificant when compared with the volume of water filling the sea. Others have compared this phenomenon with the retreating of the sea which has occurred during some of the most severe earthquakes, but as that phenomenon has not been yet accounted for in any satisfactory manner, our knowledge is not advanced by this comparison. Some think that the retreating of the sea may be effected by the rising of the bottom of the sea, in consequence of the elastic vapours underground exerting their forces against

it, and raising it above its former level. This explanation is less to be objected to than others

17 The approach of an eruption is also indicated by a diminution of the water in the wells and springs at places which lie on or near the base of the volcano. In some instances the wells are stated to have dried up entirely. It has not yet been ascertained whether or not this phenomenon precedes the eruption of all volcanoes, but the inhabitants of the places near Mount Vesuvius consider it as the most infallible of all prognostics, and on that account pay great attention to it In our times, some philosophers have also adopted this belief, and have collected several facts by which the vulgar opinion is confirmed Twelve days before the eruption of Mount Vesuvius in 1804, the water in all the wells near its base sank considerably below their common level More attention was paid to the wells in 1830, the decrease of their water was very regular In the month of May they sank more than ten feet, though very heavy rains had fallen The decrease of the waters continued during the summer months, but less rapidly, until the month of October, when a slight rise was perceptible, they then preserved their level to the months of December, when an eruption took place. The explanations which have been offered of this phenomenon are far from being satisfactory, and may on that account be omitted

18. During the time which passes between two eruptions, and when the volcano is said to be in repose, its crater undergoes several changes Immediately after an eruption it forms a deep funnel, more or less regular, but shortly before such an occurrence it is found to be filled up with volcanic matter According to the facts collected and recorded by modern observers, it would appear that the filling up of the crater is not always effected in the same way, but by two different processes.

When the crater of a volcano is examined immediately after an eruption, it is found that its bottom is deeply depressed below its rim In some cases, the declivities leading to it are so steep that it is almost impossible to

get down to the bottom This might have been expected. The immense force with which the elastic vapours act, when they escape from the bowels of the earth, has removed all the masses of lava and other volcanic materials which had previously accumulated in the crater. The last lava which was raised by them in the volcanic chimney, but for the ejection of which the decreased force of the vapour was insufficient, remained in the crater, but as it was in a liquid state it sank down to the lowest depths of the opening, to the narrow orifice of the chimney, and there it hardened as it became cold After this state of the crater has continued for some time, its bottom begins to be covered with volcanic substances and rubbish, which, in different modes, are detached from the sides of the crater and roll down, thus the narrow rents at the bottom are gradually covered with layers of scoria and of cinders When in this state, which sometimes lasts for many years, the crater of the intermittent volcano greatly resembles, as we mentioned before, that of a semi-extinct one, but after some time it begins to undergo a change It is found that the bottom is gradually raised higher and higher. This appears to be effected by the elastic vapours confined within the bowels of the volcano When either by accumulation, or by the increase of their elasticity, their force has been considerably augmented, they press on all sides on the surrounding objects, and, consequently, also against the bottom of the volcano The effects of such a pressure manifest themselves by the splitting of the bottom at numerous places, and by the rising of its whole mass. In this manner the subterraneous forces continue to raise the bottom of the volcano, until it has risen to the level of the rim of the crater, which event is commonly soon followed by an eruption, which, in this case, takes place without being preceded by any discharge of melted matter By the process just described, the crater of Mount Vesuvius was filled up with volcanic matter between the eruptions which took place in 1804 and 1813

19. But frequently, probably in the majority of cases,

the crater is filled up by a different process. It appears that the bottom of the crater is sometimes not entirely shut up by the lava which, after the eruption has terminated, falls back upon it and there becomes a solid mass. A small opening remains, by which a free and uninterrupted communication between the interior and exterior of the globe is established This opening emits, for some time after the eruption has ceased, only white vapours. But after a time these vapours begin to assume a deeper colour and at length, when their colour has grown darker, they bring up small pieces of lava, known by the name of scoria, which have been apparently torn off from the melted matter below the crater These scoria are raised to a considerable elevation by the elastic vapours escaping through the opening Whenever they get beyond the reach of the elastic vapours they fall to the ground A portion falls back into the opening, but another portion is lodged round it, where this matter soon accumulates to such an extent, as to form in time a small hill round the opening Such hills formed within the precincts of the crater are called *cones of eruption* They are entirely composed of scoria and ashes, like the cone of the volcano, but they do not move when pressed upon This is probably owing to the thinness of their walls and to the heat existing in the opening By this heat the accumulated matter is partially melted, and the whole mass becomes so cemented as to acquire a considerable degree of consistency These cones of eruption may be ascended without the least danger, and thus the opening in the midst of them may be approached nearer than can be done under other circumstances. When a cone of eruption has increased for some time and has attained some height by the continual accession of fresh matter, the subterraneous powers raise the melted matter higher, and push it into the pipe By this operation the sides of the cone are burst open at one or more places, and from the lowest part of the rents, which is always near the base of the cone, a greater or smaller quantity of melted matter is discharged which overflows the lower tracts surrounding the cone, where it soon hardens.

Meanwhile the ejection of scoria continues increasing the cone of eruption, and is from time to time attended by an effusion of lava from the base or from the top of the cone. In this manner the crater is gradually filled up by successive layers of lava, which have issued from the cone of eruption At last this cone attains such an elevation that it projects above the rim of the crater, and becomes visible to the country surrounding the volcano When this has taken place, the effusion of lava from the cone of eruption soon fills up the lower space which lies between it and the rim of the crater, and thus at last the bottom of the crater is raised to a level with its rim. Sometimes it is found that a part of it is even higher than the rim When this has taken place, the lava issuing from the cone of eruption begins to run over the rim of the crater and to descend on the declivities of the cone of the volcano and over its base This process continues until an eruption puts a stop to it by clearing the chimney, and by removing in a few hours or days the immense quantity of volcanic matter which in the course of many years has accumulated in the crater After the eruption has passed away the process just described begins its course anew

In this manner the crater of Mount Vesuvius was filled up in the interval which elapsed between the eruptions of 1813 and 1822, as also in that which occurred between the last-mentioned year and the eruption in 1834 By the violent eruption of 1822 the crater of the volcano had been so completely cleared of all the matter which had accumulated during the nine preceding years, that it presented a deep and immense cavity It was then measured by Mr Babbage, who ascertained that its bottom was 938 feet below the highest part of its rim, and 459 feet below the lowest part In this state it appears to have remained up to 1827, when it was observed that a change was going on in the bottom of the crater An opening was soon effected, from which showers of scoria were thrown up In a short time they accumulated round the orifice so as to form a

cone of eruption. In 1828 the first effusion of lava from a rent in the cone was noticed, and it was followed by a number of others during the two following years. The quantity of lava which in this manner was brought up must have been very considerable, as appears from a measurement taken in August, 1830, when the bottom was found to be only 640 feet below the highest, and 160 feet below the lowest, part of the rim of the crater. The depth of the crater had consequently decreased nearly 300 feet in two years. We may form an idea of the quantity of lava which was required to fill up the crater when we consider that, according to a trustworthy statement, the diameter of the crater at its upper opening exceeded 1900 feet. A little more than a year later, in September, 1831, the cone of eruption in the middle of the crater had been so elevated by the continual accession of scoria and other volcanic materials that its summit became visible in the town of Naples, and a few months later the whole crater was completely filled up. In the beginning of 1832 the lava began to flow over its rim and to descend in streams on the declivity of the cone which encloses the crater. Sometimes these floods of lava ceased for weeks or even months, and then began again. In this state the volcano remained for more than two years. At last an eruption took place in 1834, after which the crater was found to have entirely changed its aspect. The cone of eruption which had originated on its bottom in 1828, had disappeared with a most terrible crash, and on the newly formed bottom were only two abysses, which descended so deep that it was impossible to see their termination, and which were divided from each other by a narrow ridge.

The facts respecting the filling up of the crater between two eruptions have only been lately ascertained, and they support the assertion of the geologist Von Buch, who maintains that the approach of an eruption may be known by an examination of the state of its crater, that when the lowest part of it is but little depressed below its rim, an eruption is not distant, but that on the

other hand such a phenomenon is not to be apprehended when the distance between the rim and the bottom of the crater is considerable

20 It is very probable that the different modes in which the crater is filled up modifies the phenomenon with which an eruption commences, and also the degree of energy with which it manifests itself When the crater is filled up in the manner described in page 120, there is an opening which evidently passes through the whole crust of the earth and terminates near the spot where the matter to be ejected is heated and reduced to or kept in a fluid state. When the subterraneous powers do not assume a great degree of intensity, the matter is brought up by them in such quantities only as can easily be discharged by the existing chimney as happened in Mount Vesuvius for two years before the eruption of 1834 In such a case the eruption begins with a discharge of melted matter from the top of the volcano When in the progress of the eruption and by the increase of the subterraneous forces a larger quantity of melted matter is driven into the existing volcanic chimney than it is able to contain, it must be broken to pieces by the pressure of the matter This, however, is commonly effected with such ease, that the event is brought about without violently convulsing the mountain and the adjacent country Such eruptions, therefore, are not usually preceded by earthquakes, or they are not of such a description as to cause great damage When by the last-mentioned process the crater has been freed of the volcanic matter which encumbered it for many years, the lava in many cases finds a free exit by its mouth But when the volume of the lava is too great to be discharged, even by the much-widened mouth of the crater, it presses against its sides, which are forced open at such places as are least able to afford resistance to the immense pressure to which they are exposed. It is therefore found that in such circumstances the eruption begins at the top of the mountain, and the lateral eruptions somewhat later

All these circumstances vary considerably when the crater has been filled up in the manner noticed in page

119. There is occasionally no opening which can be widened by the subterraneous vapours without great effort. A much greater pressure is required to break open the contiguous and solid mass by which the crater has been filled in a manner which is still a mystery to us The efforts which the subterraneous vapours must make to produce such a pressure are probably the cause why the eruptions happening in such circumstances are preceded by such violent earthquakes as were experienced in 1779 and in 1794 It is usually the case, that the melted matter accumulates in the interior of the volcano before the upper part of the crater has been opened, and the lower parts of the crater being unable to resist the pressure of the matter, burst open at the weakest spots Consequently we find that in such circumstances the lateral eruptions precede the great eruption from the top of the mountain, as happened in the eruption of Mount Vesuvius in 1794

121 With a violent crash, if not with an earthquake, the crater is broken open by the subterraneous vapours, and the eruption begins Whilst it is going on a loud noise is heard from the interior of the volcano It is a continual hollow rumbling sound, similar to the roaring of the sea during a heavy gale, but interrupted by violent detonations, which resemble the explosions of inflammable gases The white smoke which, previous to the eruption, issued from the cone, assumes by degrees a much darker tint as the period of the eruption approximates, and after its commencement turns quite black It also increases rapidly in intensity, and forms a column which gradually rises higher and higher above the summit of the volcano Within this column of smoke pieces of solid matter are seen moving upwards, evidently supported and impelled by the invisible vapours issuing from the crater They are of different dimensions Some are pieces of rock of considerable size and weight They are thrown up at intervals of a few minutes and with a crashing noise. In ascending above the summit of the volcano they diverge gradually, assuming the shape of a sheaf Part of them fall back into the crater, but

many descend on the declivities of the mountain, where they roll down with a tumultuous noise, or, bursting asunder, cover the immediate vicinity with a shower of splendidly shining sparks. But the greatest portion of solid matter contained in the column of smoke, consists of small pieces of solid matter, called scoria, of sand, and ashes. By contemplating this column of smoke in the daytime the mind of the beholder is oppressed by feelings of sinister foreboding, and its emotions are kept in suspense: but in the night it is filled with a sensation in which awe and admiration are mingled, for the reflection of the light issuing from the lake of burning lava in the crater, illuminates the column and imparts to it the tint of the clouds of a thunder-storm when illuminated by the setting sun. The masses of glowing rocks rising and sinking within this stream of light greatly increase the grandeur of this awful though magnificent sight.

When this spectacle has continued for some time without any perceptible variation, a change is observed gradually to take place. The larger pieces of rock decrease in number and size, and at the same time the minute solid matter, especially the ashes, are astonishingly increased. In consequence of this change the column of smoke rises higher and higher, and when it has attained a great elevation, its upper extremity begins to expand on all sides, until it forms a very extensive cloud of a circular form, which appears in its middle to be supported by a comparatively slender columnar shaft. The whole bears some resemblance to a Chinese umbrella, or a large mushroom. The Italians compare it with that kind of pine-tree which bears edible fruit, frequently met with in Italy. This tree is distinguished by its elegant shape, a slender and straight trunk, surrounded at its upper extremity by a circular crown, formed by numerous branches, diverging in nearly horizontal lines from the stem. On that account the Italians name it *the pine*. This beautiful phenomenon, which hardly ever fails making its appearance towards the close of the eruption, is an object of admiration even in the day-time, but in the dark night it presents one of the most impres-

sive scenes of beauty which nature can afford. The column of smoke is converted into a magnificent column of fire by the reflection of the light from the crater, and its interior is literally dotted by numberless shining points of great splendour, which are the many millions of glowing grains of sand and ashes rising up and down in the column. In the column, but still more frequently in the cloud above it, flashes of forked lightning are seen every moment in all directions, and are accompanied by thunder. After this phenomenon has lasted for some hours, the cloud imperceptibly vanishes, and the column of ashes gradually disappears. The eruption is at an end.

22. Most of these phenomena appear to have attended the first eruption of Mount Vesuvius, in 79 of our æra. We have an account of this event in the letters of Pliny the younger to his friend Tacitus. Though this account is not quite satisfactory, according to our present knowledge of the subject, it must always be read with great interest, as it proves that the phenomena produced by that eruption were on a much greater scale and much more destructive than ever has been experienced in modern times, and as it involved the death of his uncle, Pliny the elder, the famous author of the Natural History.

"My uncle," writes Pliny, "was at that time with a fleet under his command at Misenum. On the 23rd of August, about one in the afternoon, my mother (his sister) desired him to observe a cloud which appeared to be of a very unusual size and shape. He went upon an eminence to view it more distinctly. It was not at that distance discernible from what mountain the cloud issued, but it was found afterwards to ascend from Mount Vesuvius. I cannot give you a more exact description of its figure than by comparing it with a pine-tree, for it shot up in the form of a trunk, which extended itself at the top into a sort of branches. This form was occasioned, I imagine, by a sudden gust of air that impelled it, the force of which either decreasing as it advanced upwards, or the cloud itself being pressed back again by

its own weight, expanded in this manner It appeared sometimes bright and sometimes dark and spotted, as it was either more or less impregnated with earth and cinders This extraordinary phenomenon excited my uncle's curiosity to take a nearer view of it He immediately ordered a light vessel to be got ready; but as he was coming out of the house with his tablets for his observations, the mariners belonging to the galleys stationed at Retina, entreated him by a messenger to come to their assistance, since that place being situated at the foot of Mount Vesuvius, there was no way for them to escape but by sea He therefore ordered the galleys to be put to sea, and went himself on board with the intention of assisting not only Resina but several other towns situated upon that beautiful coast When hastening to the place, from which others were flying with the utmost terror, he steered directly to the point of danger, and with so much calmness and presence of mind as to be able to make and to dictate his observations upon the motion and figure of that dreadful phenomenon He went so near to the mountain that the cinders, which grew thicker and hotter the nearer he approached, fell into the ships, together with pumice stones and pieces of burning black rock. They were also in danger not only of running aground by the sudden retreat of the sea, but also from the vast fragments which rolled down from the mountain and encumbered all the shore Here he stopped to consider whether he should return When the pilot advised him to that step he said, 'Fortune befriends the brave, take me to Pomponianus' Pomponianus was then at Stabiae, a town separated by a gulf, which the sea, after several windings, forms upon that shore The wind being favourable, my uncle soon reached the villa of Pomponianus, whom he found in the greatest consternation, he embraced him with the greatest affection, and exhorted him to keep up his spirits, and to dissipate his fears the more, he took a bath and sat down to supper. In the mean while the eruption from Mount Vesuvius flamed out in several places with much violence, which the darkness of the night contributed to render still more

visible and dreadful. My uncle having tried to soothe the apprehensions of his friend, retired to rest and soon fell asleep The court which led to his apartment being in the meantime almost filled with stones and ashes, if he had continued there any longer it would have been impossible for him to have made his way out, it was therefore thought proper to awaken him He got up and went to Pomponianus and the rest of the company, who had not ventured to go to bed After a short consultation, it was resolved to leave the place and retire to the fields, as the less dangerous situation They went out, therefore, having pillows tied upon their heads with napkins, which was all their defence against the storms of stones that fell around them Though it was now day everywhere else, where they were a deeper darkness prevailed than in the most obscure night, except that for moments it was dissipated by the flashes from the mountain They thought proper to go down farther upon the shore to observe if they might safely put to sea, but they found the waves still running extremely high and boisterous Here my uncle having drunk a draught or two of cold water, threw himself down upon a cloth, which was spread for him, when immediately the flames and a strong smell of sulphur, which was the forerunner of them, dispersed the rest of the company and obliged him to arise He raised himself with the assistance of two of his servants, and instantly fell down dead, suffocated as I conjecture by some gross and noxious vapours, for he had always weak lungs, and was frequently subject to a difficulty of breathing.

"Meanwhile I was at Misenum pursuing my studies. There had been for many days before some shocks of an earthquake, but they were particularly violent the night after my uncle had left us They not only shook everything about us, but seemed indeed to threaten total destruction My mother awoke me, and we went into a small court belonging to the house, which separated the sea from the buildings When it grew day the light was exceedingly faint and languid, and the buildings all around tottered. As there was no remaining there with-

out certain and great danger, we resolved to quit the town. Having got at a convenient distance from the buildings, we stopped in the midst of a dreadful scene of danger The carriages which we had ordered out of town, though standing on a level spot, were so violently pushed forward and backward that they could not be kept steady, even when propped by large stones. The sea also appeared to roll back upon itself, and to be driven from its shores by the strong concussions of the earth It is certain that the beach was considerably widened, and that many of the inhabitants of the sea were left upon the strand On the other side a black and dreadful cloud, bursting with an igneous serpentine vapour, darted out a long train of fire, resembling flashes of lightning, but much larger. Soon afterwards the cloud descending covered the whole bay, and we could no longer see the island of Caprea and the promontory of Misenum The ashes began to fall upon us, but in moderate quantities I looked back A thick black smoke, just behind us, rolled along the ground like a torrent, and followed us Soon afterwards we were enveloped in darkness, not like the darkness of a cloudy night, or when there is no moon, but such as is in a close room when all light is excluded Nothing was then to be heard but the shrieks of women, the screams of children and the cries of men, some calling for their parents, others for their children, others for their husbands, and only distinguishing each other by their voices. Some bewailed their own fate, others the fate of their relations, some wishing to die from the very fear of dying, some lifting up their hands to the gods, but the greater part imagining that the last and eternal night was come which was to destroy both the gods and the world together. At length a glimmering light appeared. We imagined it to be rather the forerunner of an approaching burst of flames (as it really was) than the return of the day. However the fire fell at a great distance from us, and then we were again immersed in darkness A heavy shower of ashes rained upon us, which we were obliged now and then to shake off, other-

wise we should have been crushed and buried in the heap. I supported myself with the consolation that all mankind was involved in the same calamity, and that I was perishing with the world itself. At last this dreadful darkness was dissipated by degrees like a cloud of smoke. The daylight returned, and even the sun appeared, but with a faint light, as when an eclipse is coming on Every object that presented itself to our eyes appeared changed, being covered with white ashes as with a deep snow"

This account of Pliny, when compared with the descriptions of more recent eruptions of Mount Vesuvius or any other volcano, may be considered as an exaggerated statement, especially that portion where he reports what happened in the vicinity of Misenum, thirty miles from the place of eruption But when it is remembered that by the volcanic matter then thrown up the towns of Pompeii, Herculaneum, and Stubiae were so buried that the highest parts of the villas and palaces which they contained were not visible above ground, we can hardly doubt of the correctness of his statements

23 There is no object in nature so calculated to create extreme surprise in our mind as the force with which the subterraneous vapours act in effecting an eruption. We know that at the eruption of Mount Vesuvius in 1834 its crater was filled with a succession of layers of lava, which formed a mass at least five hundred feet thick, consisting of very hard and compact matter This mass was removed from the crater, to which it was apparently firmly fixed, with the greatest ease, as the operation was not even attended by an earthquake We are totally unacquainted with the chemical nature of the elastic vapours by which such extraordinary changes are effected From the immense force which steam acquires when confined and exposed to a degree of heat which continually increases its expansibility, it is supposed that this elastic fluid is more active than any other in bringing about the eruptions, and this supposition is strongly supported by the immense quantity of water which descends in rain from the cloud above the column of smoke, and which appears to be produced by the condensation of the

vapours accumulated in that part of the volcanic column. When, by the escape of immense volumes of elastic vapour, the bowels of the earth have been efficiently relieved from the pressure, the eruption ceases, but only after having ejected large quantities of rocks, scoria, sand, ashes, and lava

24 During the eruption, but especially in the beginning, large pieces of rock are thrown up, as already noticed Many of them are ejected at once, the discharges, however, are not continual, but succeed one another at intervals of some seconds It is very probable that these rocks do not proceed from the interior of the volcano, but are the fragments of the lava with which the crater was filled up previous to the eruption, After having been broken to pieces by the force of the elastic vapours, they are raised from their sites and ejected They are carried to a considerable elevation, and in descending some of them fall on the declivities of the volcano, whilst others return into the open crater. This explains some facts which have been observed long ago Though many of these rocks are broken to pieces on reaching the ground, by the great momentum they have acquired in descending from an elevation of some thousand feet, a considerable number of isolated lava rocks are met with in single masses on the base of the volcano at spots where no stream of lava is found. They are mostly of small dimensions, but sometimes pieces are found of five or even ten feet in diameter. Attentive observers state that such pieces of rock are enveloped in a thin coat of more recent lava, assuming mostly the form of scoria, and that this coat is so loosely attached to the rock that it may be separated from it by the application of a small force. When the rocks return into the crater they are deeply immerged in the fluid mass by the momentum they have acquired, but they do not seem to experience such a degree of heat as is required to convert them into a fluid, which is proved by the circumstance of pieces of more ancient lava being frequently found imbedded in the streams of lava which have issued from the volcano in a fluid state.

25 All the solid matter which is emitted by volcanoes consists of the same substance it is lava As, however, it reaches the surface of the globe under different forms, these are distinguished by different names The term *scoria* is applied to the smaller pieces of solid matter, which are thrown up and reach the ground after passing through the air These scoria in their surface resemble the dross of our furnaces or coke, being full of holes and consequently very rough and uneven Their origin is not doubtful they are pieces of lava which have been detached from the surface of the melted mass in the interior of the volcano by the force of the elastic vapour These detached portions of the melted matter are probably in a different state of liquidity when they are propelled into the air When the matter is very liquid, it assumes a more or less globular shape. Numerous pieces of scoria, however, are found which have the form of a pear, one extremity being rounded off, whilst the other is elongated pieces of such a shape are called in Italy *volcanic bombes* or *tears* They are not usually of large dimensions Though many have been found of the size of a closed fist, the greater number does not exceed that of a nut Sometimes, though rarely, they are so large as to weigh from fifty to sixty pounds. The smaller ones have the most regular form They pass through the air with a hissing sound. In reaching the ground they break to pieces, when, during their fall, they have become so cold that their outer crust has attained some degree of hardness, but they are commonly in such a state of liquidity and softness that their surface easily yields to pressure, and therefore they are flattened on that side on which they touch the ground, or take the impression of the body on which they chance to fall. Some of the poor people residing near the base of Mount Vesuvius, on observing such soft pieces, press coins or other hard objects into them, which they afterwards find an opportunity of selling to curious travellers.

Many pieces of lava, however, appear to be in a semi-liquid state upon leaving the crater, but not sufficiently soft to assume the globular shape during their passage

through the air On the other hand, they have not attained such a degree of consistency as to exclude every kind of change occasioned by the resistance of the air. They are then distorted by this resistance, and at the same time puffed up by the vapours permeating their mass whilst cooling Such pieces assume very strange and distorted forms before they reach the ground, sometimes resembling twisted cables, at others trunks of trees, or icicles, or other objects Many pieces of scoria of such forms are found on the declivities of volcanoes and in their vicinity

By far the greatest quantity of scoria emitted by volcanoes is of a more minute size, and this kind is known in Italy by the name of *rapilli* or *lapilli* These pieces are in size like gravel, their surface is also extremely rough and uneven Their origin is explained in the following way —Small pieces of lava become nearly cold and hard whilst being carried through the air to an elevation of some thousand feet, when in that state they are descending towards the crater of the volcano, they meet other pieces of lava ascending under the impulse of the elastic vapours, and are again struck upward, thus they are repeatedly impelled up and down, and by continually coming into contact with other pieces of scoria, are broken and divided into small fragments These rapilli are found in layers several feet deep in the vicinity of volcanoes, and are extensively used in the composition of that excellent mortar which is called Roman cement.

26 Nothing, however, is ejected by the subterraneous vapour in such immense quantities as volcanic sand and ashes They appear to be two different kinds of matter, but are really the same substance When the substance consists of heavy, black, shining particles, it is called *sand* But more commonly it is composed of much more minute particles, and resembles fine dust or flour; it has then a much lighter colour, being either white or reddish or brownish grey As this matter greatly resembles white wood ashes, the term *ashes* has been applied to it. Sand and ashes, however, have been found to be properly lava, and differ only in the degree of comminution. The

sand resembles the lava even in colour, but when that substance is so minutely divided as to be converted into dust, it assumes a much lighter colour It is supposed that the origin of this substance is similar to that of the rapilli, both receiving their form by the continual attrition of the pieces of lava which meet one another in the air, and are brought into violent contact by the great force with which they are impelled upward and downward But modern philosophers, taking into consideration the almost incredible quantities of ashes which are thrown out at each eruption of a volcano, do not consider this explanation as sufficient For it sometimes happens that streams of ashes continue to issue from the crater for several days in succession, and that the quantity ejected is so great as to fill the atmosphere in the neighbourhood of the volcano to such a degree as to produce a complete darkness, therefore another explanation of the origin of the ashes has been suggested It is supposed that a mass of lava in a state of great liquidity is suddenly exposed to a violent rush of elastic vapour, in which event the lava must be converted into a froth, which, when ejected from the crater, is instantly divided into the most minute particles.

The quantity of ashes which are sometimes thrown up by volcanoes can hardly be comprehended. The town of Pompeii was entirely buried under the ashes which were ejected from the crater of Mount Vesuvius in 79. The quantity which issued from the same volcano in 1822 was also astonishing The ashes continued falling for twelve days, and for four days they fell very thick In places built near the base of the volcano, as in Resina, Torre del Greco, Bosco-tre-case, the atmosphere was so filled with the dust, that the darkness produced by it was as intense as in the most obscure nights, and people were obliged to carry lanthorns when they left their homes It is stated that this happened even at Amalfi, a place which in a straight line is sixteen miles distant from Mount Vesuvius, and separated from the volcano by a mountain-ridge which rises to more than four thousand feet in height. The inhabitants of that place were asto-

nished that day did not dawn, and when they observed that sand and ashes were falling down from the atmosphere, they were seized with a panic, for they had not the least suspicion that Mount Vesuvius was in a state of eruption, and besides none of the inhabitants had ever witnessed a similar fall of ashes. When the ashes had ceased falling, some pains were taken in ascertaining the quantity of that material which covered the neighbourhood of the volcano, and it was found that on the declivities of the mountain it formed a layer of about three feet, and on the plain surrounding the base of the mountain, from sixteen to twenty inches in depth.

These heavy falls of ashes are the most destructive phenomenon with which the eruptions of volcanoes are attended. They cause much more damage than the lava, for the injury resulting from the last-named material is limited to comparatively small tracts, which, being overflowed by the stony mass, are rendered unavailable to cultivation sometimes for centuries. But the ashes when they fall in large quantities occasionally crush down buildings, cover up hamlets or towns, and choke their inhabitants. Even when the quantity is not so large, they are commonly attended with considerable loss of property, as they destroy large plantations of fruit-trees and vineyards. The ashes on reaching the ground are not dry; they are soaked by the moisture of the vapours issuing from the volcano, and in that state they possess a great degree of adhesion; they therefore stick to the branches and leaves of the trees, which are covered by them with a thick coat. To ascertain the quantity of ashes which may thus adhere to trees and plants, a small branch of a fig-tree, having only three leaves and two immature figs, was weighed when covered with the coat of ashes, and was found to have the weight of thirty-one ounces; when the ashes were removed, its weight did not exceed three ounces.

But, on the other hand, there is hardly any kind of manure which imparts to the soil such a degree of fertility, and that for a great length of time, as these volcanic ashes. It is stated that every kind of seed sown in

these ashes germinates much more quickly than in any other soil, and that plants vegetate with more vigour than in the most fertile mould. To explain this fact it is supposed that the fructifying principle consists of a small quantity of salt which is intimately combined with the ashes. Considering the great degree of fertility the ashes impart to every kind of soil, many authors have not hesitated to express their conviction, in the most decided manner, that all the damage produced by a fall of volcanic ashes is abundantly compensated in a few years. The knowledge of this fact is sufficient to account for the circumstance that hardly any part of the globe can be compared in respect of fertility with the country surrounding volcanoes. This is well known respecting the plain of Campania, surrounding Mount Vesuvius, and that of Catania, extending along the southern declivities of Mount Etna. In South America, and especially in Central America, the most populous tracts are those situated in the vicinity of volcanoes.

27. With what an astonishing degree of velocity the elastic vapours must rush out from the crater of a volcano may be inferred from the elevation to which even large pieces of lava are raised by them. Sir William Hamilton observed in 1775 that some pieces of rock did not begin their descent before they had attained a height at least equal to that of the volcano itself; the summit of Mount Vesuvius is nearly three thousand eight hundred and fifty feet above the sea. During an eruption of Mount Etna an attentive observer ascertained that some pieces of rock took twenty-one seconds in descending from the elevation they had attained to the top of the volcano; they were consequently carried to a height of more than seven thousand feet. But the less heavy matter, the scoria, rapilli, and ashes are carried to a much higher elevation. The column of smoke, which we mentioned in noticing the phenomena attending an eruption, is almost entirely filled with these more minute solid substances. In some instances its elevation has been measured with some degree of exactness, and it was found, that the cloud at its upper extremity was six or seven miles distant from

the summit of the volcano. Some persons have assigned to it a much greater elevation. Incredible as such statements may appear, we are obliged to give credit to them, when the great distances are considered, to which the ashes are carried by the winds before they descend to the surface of the globe. The Greek historian Procopius states that during an eruption of Mount Vesuvius (472) its ashes were carried to the town of Constantinople. According to the statement of Sir William Hamilton, in 1794, ashes of Mount Vesuvius descended on some parts of Calabria, and fell at a place which was not less than one hundred and forty miles distant from the volcano There are instances on record of ashes ejected by Mount Etna being carried to Malta, though the distance between the two places exceeds one hundred and twenty miles. Still more astonishing is the fall of volcanic ashes on the island of Java, which happened in 1815, and is mentioned by Sir Thomas Raffles It proceeded from the volcano of Sumbawa, which is about two hundred and eighty miles distant from the eastern extremity of Java Yet the quantity of ashes which fell on the eastern districts of this island were sufficient to form a layer eight inches deep

One of the most remarkable falls of ashes was that which descended on the island of Barbadoes on the 1st of May, 1812 The day previous to that date, an eruption of the volcano of St Vincent occurred, and the detonations with which the breaking up of the volcano was attended, were so intense that they were heard in the island of Barbadoes As it was during the war, they were taken for the firing of cannon. On the morning of the 1st of May a dark cloud was observed advancing towards the island from the west A short time afterwards it descended and enveloped the whole island in the deepest darkness, accompanied with a very heavy fall of ashes Persons who were out of doors were unable to see the trees, under the foliage of which they had taken refuge, in the houses it was not possible to distinguish the openings of the windows The ashes continued falling till noon, and then the quantity which had descended had so

increased, that the branches of the trees were bent to the ground, and the canes of the sugar plantations were crushed. This phenomenon excited a great deal of astonishment, partly on account of the distance of the two places, which exceeds a hundred miles, but still more from the circumstance, that the ashes had been carried against the trade-wind, which in these parts, particularly at that season of the year, is very constant and blows with considerable force. No satisfactory explanation can be given of this strange event, unless by supposing that the elastic vapours, on being released from the bowels of the earth, escaped from the crater of the volcano with such an impetus as enabled them to carry the ashes through that region of the atmosphere in which the trade-winds blow, and to raise them to the elevation in which, according to the theory of the trade-winds, a current of air exists in a direction diametrically opposed to that of these winds

28. In enumerating the phenomena with which an eruption is attended, it was stated that towards its close the column of smoke rises to an immense elevation, and expands at its upper extremity uniformly on all sides, so as to form a circular cloud of immense diameter resting on a proportionally slender and very high column The constant recurrence of this phenomenon has, of course, excited the attention of natural philosophers, who try to explain it in the following manner when the ashes carried up by the elastic vapours attain a great elevation, they begin to descend towards the crater by the effect of their gravity as soon as the force of the elastic powers begins to decrease. When thus descending they meet in their way the ascending ashes The elastic vapours which propel these ashes upward, resist the impulse which has been imparted by their gravity to the descending particles, and compel them to rise again As, however, the mass which they have to sustain is in this manner greatly increased, the elastic vapours are unable to overcome entirely the resistance opposed to their rising in a perpendicular line, and a portion of them is thus pressed out on the sides. This process going on for some time,

the upper extremity of the column begins to spread, and by degrees forms in the air that hanging circular roof on the top of the column

In this cloud phenomena are constantly observed which apparently originate in electricity. Flashes of forked lightning, frequently a dozen at once, are seen rushing through the cloud in zigzag lines in every direction, and they are attended by a rolling thunder, which may easily be distinguished from the rumbling noise proceeding from the bowels of the volcano Though all circumstances concur to impart to these phenomena an electric character, the naturalists for some time doubted whether they owed their origin to electric matter. They were rather inclined to consider them only as explosions of inflammable gases Such explosions, however, could not kill persons at a great distance from the spot where they originated This has, however, sometimes happened. Thus it is recorded that, during an eruption of Mount Katlugia, in Iceland, in 1755, the lightning originating in the volcanic cloud killed eleven horses and two persons, and some rocks standing in their way were perforated with cylindrical holes. This proves them to be real electric phenomena

Their origin may be also satisfactorily explained by the well-established laws of nature By numerous experiments it has been proved that electricity is developed when aqueous vapours are condensed and converted into water, or when water passes into steam It can hardly be questioned that the first kind of process is continually going on in a volcanic cloud of such dimensions. We cannot doubt that the condensation of hot vapours must be very rapid along the periphery of the cloud where the vapour comes into contact with the much colder air of the atmosphere surrounding the cloud. In this part of the cloud therefore the electric phenomena ought to be very frequent, almost incessant, and so it is The most exact observers state unanimously, that the strongest flashes of lightning are observed to spring from near the outer edge of the cloud, and that usually they thence pass towards its centre.

29. The most remarkable of the volcanic productions is the lava It has been stated that, a long time before an eruption takes place, small quantities of lava frequently issue from the cone of eruption in the middle of the crater, and that its cavity is gradually filled up by them. It has also been noticed, that when no cone of eruption is formed in the crater, the lava sometimes forces its way through the sides of the volcano before it succeeds in breaking open the centre of the crater. But by far the largest quantity of lava is emitted during the eruption.

When a cone of eruption exists in the crater the approach of the eruption is indicated by the appearance of fire, which is observed for many days or even weeks on the top of the mountain This is not an actual fire, but only the reflection of the melted and hot masses which are alternately ascending and descending in the volcanic chimney The light issuing from them is reflected by the vapours, which are continually evolved from the burning mass and escape through the orifice of the chimne

The lava is for a long time ascending and descending in the volcanic chimney before it rises so high as to attain its orifice, and, running over the rim of the crater, descends on the declivities of the volcano to the lower countries This delay is easily accounted for, when it is considered that it is by the increase of the expansive powers of the elastic vapours that the lava is expelled from the bowels of the volcano These powers are doubtless continually on the increase When their intensity is considerably augmented they press on the lava in the volcanic chimney and raise it to some elevation, but soon find the means of escaping through the liquid matter in the form of vapours and smoke When, however, the vapours have for a longer time been exposed to a very intense degree of heat, their expansi ity is augmented to such a degree that they are enabled to raise the whole mass of lava to a great elevation, and to form a counterpoise to a column of such matter several thousand feet in height. Then the lava is pushed up to the very orifice of the chimney, and overflows the rim of the crater.

30. The manner in which the lava runs from the crater is so natural that it does not require to be farther noticed. But when it breaks out of the sides of the volcano, this event is attended by some phenomena which deserve to be noticed. It frequently happens that a lateral eruption takes place whilst the lava is running out from the crater at the top. In such a case it ceases flowing from the crater, and though the other phenomena of the eruption continue, they are commonly observed to abate perceptibly. The lateral eruptions are effected by means of rents It would appear that whilst the lava is gradually raised higher and higher in the volcanic chimney by the increased expansion of the elastic vapours, and consequently presses with greater force on its sides, it often happens that at some spots the sides of the mountain are not strong enough to resist the pressure They give way at such places by bursting open and forming a chasm. These chasms are sometimes of great length During an eruption of Mount Etna a chasm was formed which began at the top of the cone and extended for more than ten miles to a place called Nicolosi Before Mount Vesuvius opened its crater in 1794 its western side burst with a chasm, which, at its upper extremity, was two hundred and forty feet wide and more than three thousand feet long. The bursting of these chasms is accompanied with a very loud crash. As these chasms extend far below the level which the melted matter has attained in the volcanic chimney, the lava presses into the opening, but as the pressure, of course, is greatest at the lowest extremity of the chasm on which the whole column of lava in the chimney above it presses with all its force, the lava issues from that spot in greater abundance and with great violence. Consequently an opening of considerable dimensions is soon formed. The lava in the chimney sinks down to the level of this opening, and a portion of the elastic vapour soon finds its way through it. These outpourings bring with them scoria and ashes, which are lodged on the sides of the opening, and thus a cone of eruption is soon formed. But when so much of the melted matter has run out through this cone of

eruption that the mass in the chimney sinks below its level, the flow of the lava, of course, ceases, and only scoria and ashes are thrown up, by which the cone of eruption is considerably increased in size. Now it occasionally happens that the opening in this cone of eruption is blocked up either by an accumulation of scoria and ashes, or more probably by a portion of the lava getting so cold as to lose its liquidity As soon as this vent is closed the heat in the chimney is increased, and with it the expansion of the subterraneous vapours. This again raises the mass in the chimney, and the consequence is another pressure In such circumstance the old chasm opens at a lower point, and is prolonged towards the base of the volcano At its lower extremity lava runs out, and another cone of eruption is soon formed, which lies below the first on the same line This process is sometimes repeated several times On the declivities of Mount Etna twelve such cones of eruption are found lying one below the other in a straight line It is reasonably conjectured that they have been formed by the same chasm, which must therefore have been subjected to twelve breakings up. Several of them are also met with on the sides of Mount Vesuvius When these cones of eruption are of small dimensions, it commonly happens that they disappear after a time, the loose matter of which they consist being dispersed over the adjacent grounds But there are still many found which are of considerable size. When by the lapse of time and the effect of the atmospheric moisture the volcanic matter forming their surface has been decomposed, and changed into a rich mould, these hills soon become covered with vegetation, and are generally found overgrown with bushes and trees. In such a state these conical hills impress a peculiar character of beauty on such volcanic regions.

31 It is a remarkable fact that the frequency of the eruptions appears to be in an inverse proportion to the height of the volcanoes The lower the volcano, the more frequent are its eruptions Those volcanoes which are permanently active, as Stromboli on the Lipari islands, and Isalco in Central America, are comparatively only large

hills. The first-mentioned of these two volcanoes attains an elevation of only 2878 feet above the sea level Mount Vesuvius is but about a thousand feet higher, yet its eruptions occur only at intervals of many years They are, however, much more frequent than those of Mount Etna, which rises to 10,280 feet The Peak of Teneriffe, which is 12,380 feet high, very rarely has an eruption, and the colossal volcanic cones which crown the great masses of the Ecuadorian Andes, do not exhibit a decided activity more than once in a century.

Not less remarkable is the fact, that from the volcanoes of small size the lava always flows off by the crater, but in those of larger dimensions the heated matter is frequently discharged by lateral eruptions From Mount Stromboli the lava always issues from the crater, and never by a lateral rent In Mount Vesuvius both kinds of eruption are in most cases united. Sometimes all the volcanic matter is thrown out from the crater, but frequently one or two lateral rents are formed, from the apertures of which large quantities of lava are discharged. In Mount Etna the lateral discharges of lava are much more frequent than those from the top of the volcano. Dolomieu thinks that the eruptions from the crater at the top are in proportion to those by lateral rents as one to ten The Peak of Teneriffe, as far as our historical knowledge reaches, has never discharged lava from the crater at its top, which appears only as a solfatara of moderate activity, its lava has always been ejected by apertures in the sides of the mountain. The largest volcanoes in the world, as those of the Andes, do not appear to throw out lava, for with the exception of Mount Antisana, at whose base Humboldt observed a small stream of lava, he could not discover that substance in their vicinity The volcanic matter issues from them only in the form of scoria and volcanic ashes.

These two facts appear to be connected with each other, and to arise from the same cause. Perhaps they may be explained by supposing that the differences mentioned depend on the state of liquidity in which the volcanic matter reaches the orifice of the chimney. In

low volcanoes the melted mass is nearer the seat of heat, and consequently it enters the chimney and rushes out of it in such a state of liquidity, that it never possesses that degree of consistency which would be required to shut the chimney and crater completely Therefore these smaller volcanoes never have their activity interrupted. In volcanoes of middling size, as in Mount Vesuvius and in Mount Hecla, the melted matter reaches the orifice of the crater in such a state of liquidity only when the heat in the interior has attained a great degree of intensity When this heat begins to diminish, the melted matter gets cold on its surface and consolidates, and thus the volcanic chimney is blocked up, and does not re-open until the heat in the interior has again acquired such intensity as to melt the lava, and to break its upper crust by the expansive power of the elastic vapours The volcanoes which exceed ten thousand feet in elevation, have the orifice of their volcanic chimney so far from the focus of heat, that the lava which obstructs the passage can only be melted and thrown out in extraordinary cases, and even then it more frequently breaks through the sides of the volcano, than through the crater at the top. The colossal volcanoes of the Andes have their roots in an extensive mountain-mass, whose elevation above the sea-level varies between eight and ten thousand feet The melted matter in their volcanic chimneys must therefore rise to that elevation before it can break out at the base of the volcanic cones Ere it attains such a height, it may be supposed to have become so cold as to be hardly liquid, and therefore no lateral eruptions appear to have ever occurred, except at the base of Mount Antisana, as already observed. At a great distance below the orifice of the chimney, the surface of the melted matter in the bowels of the earth has probably acquired a degree of consistency bordering on that of a solid body The liquid matter is covered with a solid crust, like the water of our lakes in winter with ice The elastic vapours rushing up from below break this crust into pieces, and raise it in the chimney, but its gravity prevents it from being ejected, until the pieces of the rock are broken into

scoria or even converted into ashes by being tossed about for a length of time in the volcanic chimney. This theory is perhaps sufficient to account for the fact, that these volcanoes never emit lava, but only immense quantities of scoria and ashes.

32. The manner in which the lava is disgorged from the crater of an intermittent volcano during an eruption has not been observed, on account of the danger with which any approach to it at that time is attended, but the breaking out of the melted matter from lateral rents has frequently been seen. It would seem that the velocity with which the lava rushes from such an opening is in an inverse proportion to the elevation of the opening. The less elevated the opening, the more rapid the rush of the burning stream. When, in 1794, Mount Vesuvius made one of its most memorable eruptions, the lava issued in the night from an opening which was only one thousand six hundred and fifteen feet above the sea. Many persons who observed it from the flat roofs of the town of Naples, stated that they had seen the burning mass shot out from the opening in parabolic lines. Sir William Hamilton had, in 1767, an opportunity of observing such an eruption, and describes it in the following manner —"On a sudden I heard a violent noise, and, about a quarter of a mile off the place where I stood, the mountain split, and with much noise from this new mouth a fountain of liquid fire shot up many feet high, and then like a torrent ran directly towards us. The earth shook and at the same time a torrent of pumice-stones fell thick upon us, in an instant clouds of black smoke and ashes caused almost a total darkness, the explosions from the top of the mountain were much louder than any thunder I ever heard, and the smell of sulphur was very offensive" All eye-witnesses agree in stating, that the lava issues from the lateral rents with a violent rush. This probably is partly the effect of the great pressure with which it is driven out,* and partly of the state of extreme liquidity of the melted matter.

33. At a short distance from the opening the lava begins to run with a regular current, similar to the water in

a river. At its upper end, the stream is of narrow width, but it grows wider in proceeding farther downward. Whenever the liquid mass meets with an obstacle to its straight course, it divides into two or more branches, which, however, usually join again somewhat lower down. When the surface over which the stream runs presents a steep descent, the liquid mass shoots down in a cascade, and after having collected below it, it continues flowing, until a depression in the ground, or the diminished declivity of its surface, puts a stop to its farther progress. At the lower extremity of the stream, the matter unites so as to form a pond or lake Sometimes, however, as is frequently the case with the lava of Mount Vesuvius and Mount Etna, the stream reaches the sea, and, in pouring its contents into the water, encroaches on its dominions In day-time, unless the observer is quite close to the stream, the lava has no appearance of fire; only a white thick smoke is seen, which marks its course. At night it affords a most magnificent spectacle, that of a burning river descending from the declivity of a mountain

34 During its course the liquid matter undergoes a succession of changes Having been exposed to the air for a short time, the lava begins to lose a portion of its heat by radiation, and assumes on its surface a greater degree of consistency. The heat which is evolved from the mass soon diminishes so much, that the lava may be closely approached without danger at no great distance from the spot where it left the mountain At such places experiments have been made to ascertain the degree of consistency of the matter. Large stones thrown on it with great force do not sink, they make but a slight impression, float on the surface, and are carried down the stream Some attempts have been made to push a sharp-pointed stick into the running matter, but they were attended with very little effect, the impression was but slight, though the lava appeared to be as liquid as water. In this state the matter runs very regularly, and almost without a noise The only sound which is heard is a kind of bubbling, produced by the evolution of the vapours from the hot matter From time to time a crack-

ling is audible, which arises from the lava passing with greater force at some places. These feeble sounds, and the quiet flow of the red-hot masses, contrast in a very striking and not unpleasant manner with the continual and thundering explosions on the top of the volcano, and the loud crashings proceeding from its interior

Lower down, the surface of the lava assumes a different aspect When the consistency of the matter has so far increased as to impart to the upper layer a considerable degree of viscidity, its surface begins to be partly covered with solid matter of a peculiar form and description The heat is evolved from the mass in the form of bubbles of vapour. These bubbles in passing through the viscous layer raise a portion of it, impressing on the raised matter their own form Many of these protuberances are solidified during the process, and the stream appears to be strewed with little eminences of a conical form, which at their highest point are perforated by one or more small openings, by which the vapours find a vent When, however, the matter has not attained that degree of consistency completely, only the most elevated portion of the protuberances are solidified, and the lava being still soft gives way Then the cone-formed eminences fall into the stream, where they preserve their shape, forming small funnel-shaped depressions, which bear some resemblance to the eddies which are observed near the pillars of bridges. Some of these depressions are several inches in diameter. Thus the surface of the burning stream is by degrees covered with alternate eminences and depressions, flowing down with the current, which imparts to the whole mass a very peculiar aspect

Still farther down it is found that the stream of running lava is bridged over by a layer of scoria This change is produced in the following mode From the sides of the slowly advancing mass hot scoria falls down, which by degrees accumulates on its sides so as to form a dyke, similar to those dykes by which rivers are prevented from inundating their adjacent countries. The lava now begins to run in a channel of its own construction. When the dykes on the sides have been raised by the

continual addition of new scoria to such an elevation that they are equal in height to the upper surface of the stream, the bridging over of the mass begins from either side. The pieces of scoria which are floating on the surface of the mass are arrested by some projecting piece united to the dykes, and are soon cemented together by the heat radiating from the mass below Other pieces of scoria are soon attached to them in the same way, and thus layers of scoria are formed on the surface of the running lava, which gradually approximate to each other until they meet in the middle and are united The lava then begins to run beneath an arched vault. It sometimes happens that the lava having left the vault is not succeeded by any body of running matter The vault preserves, of course, its form, and thus it happens that hollow cylinders or pipes of great dimensions are frequently met with Sir William Hamilton describes several cylinders of this kind Their outer surface presented the greatest imaginable roughness and unevenness, but in the interior he found their sides as smooth as if they had been polished, which he with reason ascribed to the hot lava having for many weeks run through them. At many places he found large pieces of indurated lava attached to the sides or upper surface of the vault, and many of the rents which occurred there were incrusted by beautiful efflorescences of salt Some of these cylinders have been found fifty yards long and upwards In some parts of Iceland they are very numerous.

The forming of these pipes, however, can only take place when the lava descends a declivity having a regular slope. As this is rarely the case, the hollow cylinders of lava are not of frequent occurrence When the slope is irregular, as is commonly the case, the upper part of the vault is broken down, and separated into many pieces. These large pieces of scoria, of course, fall on the running lava, and are carried away with it. They rapidly increase in number by the accession of other pieces; so that at last the whole surface of the stream is completely covered with them When therefore a stream of lava is examined near its termination, this matter, which near its

source is a glowing fiery mass, appears to be nothing but a heap of black rough pieces of scoria, huddled together in an irregular manner, but which are in continual motion. When these pieces jostle and are pressed against each other they emit a peculiar sound, not unlike that produced by small pieces of glass tossed together. Only where a small interstice occurs between the masses of scoria can the red-hot lava be perceived flowing under the black layer. It sometimes happens that whilst the great mass is slowly continuing its course, a portion of it is detached, breaks through the dyke, by throwing the scoria aside, and running out with the pure clear colour of fire, alarms the looker-on who chances to have approached too close to the spot

35. There is probably no other liquid matter which is possessed of such a degree of cohesion as the running lava We must come to this conclusion, when we find that this matter does not spread over the inclined plane down which it runs, but forms a ridge, having exactly the shape of an embankment, or a rampart with regularly sloping sides. The ridge has commonly a considerable height. Even small streams of lava are found to rise from ten to twelve feet above the adjacent ground. Larger streams are sometimes from forty to fifty feet high. The lava which issued from the Skaptaar Yokul was at some places from ninety to a hundred feet above the ground over which it had flowed

It must not, however, be supposed that the whole mass of lava advances with the same degree of rapidity. That portion which forms the upper surface runs quicker than that which flows near the solid surface of the earth. This portion of the stream has not only to overcome the pressure of the mass above it, but also the inequalities of the ground over which it passes. Its progress is therefore considerably slower The effect of this difference is that the upper layers are always sliding over those below them, and consequently it is found, at the lower extremity of the stream, that the lava advances by the upper layers involving the lower ones. As in the meantime quantities of scoria are falling down from the upper

layer of the stream, the descending lava finds its way, paved, as it were, by such pieces of volcanic matter When therefore a stream of lava is examined after it has ceased flowing, it is found that not only are its surface and sides covered with scoria, but also that it rests on a stratum of such volcanic matter, which, however, is firmly attached to the lava, the scoria having been partially remelted by the hot matter which covered it

36. In several accounts of volcanic eruptions, instances are mentioned in which the lava has been observed flowing up-hill. This phenomenon is explained as follows. When the flowing stream of lava arrives in its progress at an eminence elevated several feet, and is therefore compelled to change the direction of its course, it cannot be effected suddenly on account of the heaviness of the matter and its cohesion. Meanwhile it is pressed forward from behind by the whole mass which descends from the place of eruption. By means of this pressure it is forced in a straight line up the eminence opposing its progress until it can escape on one or the other side At such places therefore it appears to flow up-hill This is also the reason why hills of lava of considerable dimensions are met with at places where the matter has been compelled to ascend by any such cause.

37. Another phenomenon has still more attracted the attention of eye-witnesses, and exercised the ingenuity of natural philosophers. When a running stream of lava approaches a high wall which extends exactly across its course it does not touch it, but stops at a distance of a few inches. When that enormous mass of lava was descending from Mount Etna, in 1669, which partially destroyed the town of Catania, it advanced to the strong walls of a convent of Benedictines, but turned aside without touching them. This fact was considered as a miracle by the inhabitants At the same time the Castle of Catania was surrounded by high masses of lava, which, after having filled up its moats containing sea-water, stopped a very short distance from the walls. In 1808 an eruption took place in the island of St. George, one of the Azores. One of the streams of lava ran to the

convent of the Ursuline nuns. At its approach the nuns appeared on the walls with the image of their saint, and when the lava had approached close to the walls it turned aside and flowed into the sea. This was of course also considered as a notable miracle. Philosophers, rejecting such an explanation, have accounted for the phenomenon in a different way. They say that this singular fact is to be ascribed to the resistance produced by the aqueous vapours which evolve from the slowly advancing mass. These vapours are compressed in the narrow space between the lava and the walls, from which they can only escape at the top. Their expansibility is thus increased to such a degree that they are enabled to stop the progress of the mass and to turn it aside.

38. In some accounts of eruptions it is stated that flames have been seen issuing from a stream of lava. it was therefore formerly supposed that the lava contained inflammable matter. But modern writers have discovered that these flames are to be ascribed to the combustion of heterogeneous matter When the lava reaches such parts of the country as are covered with vegetation, all the grass and plants are dried up at its approach by the heat evolved. The scoria falling down from the extremity of the advancing lava pushes these dry vegetable matters forward, so that after a time a heap of it is seen in front of the stream. Now it must sometimes happen that these heaps of dry grass come into contact with the red-hot lava, and then they take fire in an instant, and produce the flames that have been noticed.

When a stream of lava comes into contact with a large tree, it sometimes occurs that the lava touches the tree only on one side. In such a case that side of the tree which was in contact with the lava is converted into charcoal, whilst the other continues to vegetate. When the tree is surrounded by the lava, the heat radiating from the mass causes that part which is above the stream to take fire, and it is consumed with flames resembling flashes of lightning. But the lower part of the trunk, which is suddenly enclosed on all sides so that the access of air is excluded, is not consumed; its exterior parts are

converted into charcoal, whilst the pith is dried up. It is therefore not a rare occurrence to find charcoal and brown dry pieces of wood imbedded in the lava When by the lapse of time these imbedded trunks have been decayed by moisture and other causes, the lava is found to be perforated by a number of perpendicular cylindrical holes, resembling exactly the form of the trees.

Occasionally a very loud report, similar to the firing of a cannon, attended with a flash of lightning, is heard to proceed from a stream of lava. This happens when the lava runs over a swampy ground or a very moist soil. The sudden conversion of the water into steam and its decomposition, produce a commotion which for some moments is able to stop the progress of the stream The steam breaks with great noise through the mass, tears asunder the crust of scoria which envelopes it, and throws both the lava and the scoria into great confusion. As a portion of the steam is decomposed the hydrogen explodes and produces the loud report above mentioned, with the accompanying flash.

39 The influx of the running lava into the sea has given occasion to many elevated poetical descriptions. It is represented as an awful spectacle, as a struggle between two inimical elements But in all these pictures the event is much exaggerated, though the facts which give rise to them are true to a certain extent. When the hot lava reaches the sea, the water with which it comes into immediate contact is suddenly raised to the boiling temperature. It is consequently converted into steam, which process is attended with a loud hissing sound. But as by the conversion of the water into steam a great quantity of caloric is absorbed, the cold which is thus generated speedily converts the surface of the glowing mass into a thick and solid crust, by which all communication between the liquid lava and the sea is directly intercepted. Then the sea-water sinks, of course, below the boiling point The hardened lava is, however, pushed farther into the sea by the succeeding masses, and thus the sea is compelled to recede. In this progress the lava frequently splits, but in the same mo-

ment the aqueous vapours issue from the rent with such a violence that the water is prevented from penetrating into its recesses. Whilst this process is in action the water becomes turbid to some distance from the lava, and fish which chance to be in the vicinity are killed

The masses of lava which are thus protruded into the sea are sometimes of very considerable dimensions At the eruption of Mount Vesuvius in 1794, a stream of lava, after destroying the town of Torre del Greco, entered the sea, and drove it back to a distance of 380 feet from its former shores The width of this mass is, according to an exact measurement, 1204 feet. It is elevated fifteen feet above the sea, and is believed to have an equal depth under water The lava therefore which entered the sea during this eruption forms a mass of more than thirteen millions of cubic feet The streams of lava flowing from Mount Vesuvius which have reached the sea are numerous, as may be inferred from the fact that the eastern shores of the bay of Naples, between Portici and Torre dell' Annunziata, which two places are about ten miles distant from each other, are formed by a succession of promontories composed of lava. The same observation applies to the eastern shores of the island of Sicily, where the coast between Taormina on the north and Catania on the south, a distance of more than thirty miles, consists of high cliffs of lava, with only a few spots between them of low tracts of moderate extent covered with a soil deposited by the sea At some places, as for instance near Aci Reale, these lava cliffs are more than fifty feet high

40 In the published accounts of eruptions we find that particular care has been taken to notice the velocity with which the stream of lava advanced By comparing these statements it is found that the difference in this respect is very great. As an instance in which the lava ran with extraordinary rapidity that of Mount Vesuvius in 1794 may be adduced This stream of lava took only six hours to run from the spot of the eruption to the sea, a distance of more than four miles Much greater still was the velocity of that stream which, in 1804, broke out from the southern declivity of Mount Vesuvius. It is

said that it moved forward with the rapidity of wind. In a few minutes it had reached the vineyards, and an author asserts that in four minutes it passed over a space of three-quarters of a mile in length, though the slope over which it ran was very gentle It appears that in these two instances the lava broke out at a place not greatly elevated above the level of the sea, and that in such cases the lava is possessed of a very high degree of liquidity, which of course must greatly promote its rapid progress, perhaps more so than a greater declivity of the descent The above-mentioned stream reached the sea five hours after it had issued from the volcano. As the melted matter had its consistency continually increased by the radiation of the heat and its exposure to the atmosphere, it is evident the stream runs slower the farther it advances from its source. This appears also to be the reason why the streams of lava get wider in proportion as they advance from the spot where they left the volcano

Numerous instances are also recorded of streams of lava which advanced very slowly. A still living observer found a stream on the declivities of Mount Etna which had continued flowing for nine months, and did not advance more than five feet in twenty-four hours It is stated that a stream of lava broke out at the base of Mount Etna in 1614, which continued in motion for ten years, and in this time did not advance more than about two miles.

41. The philosophers who have made the phenomena attending eruptions an object of their most assiduous researches, have been particularly anxious to ascertain the degree of heat of the lava, when it leaves the bowels of the volcano. They think with reason that by this fact being well known they would be enabled to form some idea of the degree of heat employed in the interior of the globe to melt the matter there collected. The shortest way of ascertaining this point would doubtless have been, to measure by a pyrometer the heat of the lava at its efflux from the volcano. But no attempt of this kind could be made, because the heat radiating from the lava near its source is so intense that it is im-

possible to approach the mass within a distance of thirty or forty feet. The possibility of placing the instrument so as to make it available for the required observation is therefore quite hopeless.

The want of such direct observation has given rise to a difference of opinion among the philosophers themselves. Some are of opinion that the heat of the lava cannot be very intense They think it probable that it does not equal the heat which we are able to produce in our furnaces. They are inclined to consider the lava as a kind of liquid pap, strongly heated, and compare it to clay which has been well soaked with water, and thus has attained a degree of cohesive liquidity; but they deny that the nature of the particles of this mass is changed by the heat. Others, and among them the most conspicuous of the living philosophers, consider the degree of heat possessed by the lava, as being at least equal to the most intense heat we are able to produce by artificial means. The flowing lava is, in their opinion, a substance completely melted, like molten metals or glass, which acquires its solidity only by cooling, and not as an aggregate of solid particles, which during their state of liquidity are gliding over each other.

To support this opinion they have collected a number of facts, and made several experiments They first point out the state of extreme liquidity in which the lava issues from the volcano. It has, as already stated, been frequently seen spouting out like a fountain in parabolic curves, it sometimes runs down a declivity with a velocity which can only be compared to that of a torrent; it has in some cases been found to flow, in the space of an hour, over a distance of four thousand feet, as at Mount Vesuvius in 1804 When such a heavy matter as lava runs so quickly, it must be extremely liquid, and must therefore be completely melted. But it is known, that lava is one of the substances which can only be reduced to such a state by the application of a very intense degree of heat.

Several facts have been recorded, proving that the flowing lava is able to melt masses of rock, and pieces of

ancient lava An Italian naturalist who visited Mount Vesuvius during its eruption in 1779, observed in the crust of a stream of lava one of the funnel-formed openings, through the orifice of which he saw the lava in a constant state of ebullition The sound which issued from the opening resembled that murmuring noise which is heard when a fat liquid is boiling He threw into the opening several pieces of scoria, which he picked up in the neighbourhood, and observed that these scoria soon became hot, and shortly afterwards melted like pitch When Spallanzani became acquainted with this fact, he tried to melt such scoria by artificial means, to effect which he was obliged to apply a degree of heat in a reverberatory kiln which was sufficient to melt iron Nevertheless, the place where the Italian naturalist made the experiment was at a considerable distance from the opening in the mountain from which the lava had issued

When the running lava, after reaching inhabited places, comes in contact with metallic substances, it effects such changes as could only be produced by the application of the most intense heat This was ascertained beyond all doubt with regard to the lava, which, in 1794, destroyed the town of Torre del Greco It was found that glass had been transformed into a milk-white, transparent, stony mass, and it was then mentioned, that in 1767 some vessels of glass had been melted by the lava running under the place where they stood Iron had been puffed up so as to occupy three or four times its former volume, and its internal texture was entirely changed Other metals had undergone similar, or even greater changes The chemists, examining all these changes with attention, and comparing them with those effected in these metallic substances when placed in furnaces, came to the conclusion that the lava which issued in 1794 from Mount Vesuvius must have possessed, when it came to Torre del Greco, a degree of heat which was, at least, equal to that required to melt iron Iron can only be melted, according to the experiments of the most accredited chemists,

when the scale of Reaumur has risen to 6060° or that of Fahrenheit to 13,667°. Torre del Greco, where these metals were thus changed, is at least three miles from the place where the lava left the mountain, and in arriving at this distance the melted matter had been exposed for six hours to the effects of the atmosphere

When all these facts and experiments are duly considered, we cannot but agree with the opinion of Sir James Hall, that the heat in the interior of the volcano must be much more intense than is required to melt the stony mass of the lava into a perfectly liquid body, and that consequently it greatly exceeds any degree of heat, which we are able to produce by artificial means.

42. We may arrive at nearly the same conclusion on considering the length of time it takes before the lava gets quite cold. Its surface, indeed, soon becomes so cooled as to be covered by a crust of solid matter; and it is probable that this is partly accelerated by the vapours escaping from the interior of the mass. The solid covering is composed, as already stated, of scoria This matter is a very bad conductor of heat; the refrigeration of the mass therefore goes on very slowly. This is proved by the fact, that it is possible to pass over a stream of running lava, when covered with scoria, without sustaining any injury Sir William Hamilton, when examining the lava which had issued from Mount Vesuvius in 1779, had very closely approached to a stream, when, by the change of the wind, he found himself suddenly exposed to a very thick cloud of suffocating vapours, and a current of extremely hot air The nature of the locality prevented him from retracing his steps, and he was aware that he was in danger. But his guide extricated him from this perilous situation, by informing him that it was possible to pass over the lava. He got over without making any perceptible impression on the surface of the stream, and without experiencing any inconvenience, except a very sensible degree of heat beneath his feet He therefore recommends this course to persons who find themselves unexpectedly enclosed by the sudden separation of a

stream of lava into two arms, as sometimes happens. That a stream of running lava may be passed in this way was shown by the inhabitants of Torre del Greco in 1794, who, only twelve hours after their town had been overrun by the lava, returned to their homes, passing over the stream which was still flowing

The layer of scoria, enveloping the lava on all sides, being, as we stated before, a bad conductor of heat, is of course unable to abstract the caloric quickly from the flowing mass so as to promote its consolidation. But this circumstance alone is certainly insufficient to account for the well-established fact, that the lava preserves for a great length of time, for many months and even years, a very high degree of heat. Spallanzani, in visiting the summit of Mount Etna in 1788, passed a stream of lava, at the base of the cone, which had ceased running eleven months before, but was still smoking In the crust of scoria he found some rents, through which the still red-hot matter was perceptible even in the light of day, and a stick which he pushed into one of these rents caught fire immediately Sir William Hamilton made the same experiment with the lava of Mount Vesuvius, five years after it had left the volcano, and he mentions several instances of lava having been found still smoking three, or even five years, after it had issued from the mouth of the volcano. Such facts compel us to assume, that the lava has been heated in the great furnace of nature to a degree of intensity of which we can form no idea, for want of any kind of experience which could serve us as a point of comparison.

43. When the lava, after having become solid, is examined, it is found that it is a hard sonorous mass. Its outer surface presents nothing but a succession of irregular cavities and depressions, resembling bubbles which have burst. Where no disruption, translocation, or swelling of the interior has occurred, the mass is extremely rough, and resembles coarse porous scoria full of holes. Below this layer of scoria the lava continues to enclose bubbles, but they grow smaller in proportion as we penetrate deeper, and at the same time these bub-

bles occur at greater distances from each other. Towards the middle of the mass they disappear entirely; for the lava there forms a compact and uniform substance, without any trace of the peculiar form which it assumes in the scoria.

The occurrence of the bubbles in the lava is easily accounted for They owe their origin to the escape of the vapours from the interior of the mass whilst cooling. As the process of refrigeration proceeds from the exterior to the interior, while the vapours and gases take an opposite course, they soon arrive at those parts of the mass which have already attained such a degree of consistency as not to yield to the pressure of the vapours, and consequently they are there stopped and shut up.

Though the lava is a compact and uniform mass, it is not always of the same mineralogical character, but differs according to the proportion of the various substances which have been subjected to the process of melting in the bowels of the earth It is even found that the lavas of the same volcano, which have been ejected at different periods, varied considerably, if examined in their component parts. Mineralogists distinguish a considerable number of lavas, and have arranged them under two principal heads, the *stony* and the *glassy* lavas. The first-mentioned class comprehends those which have the appearance of hard stones; their texture is sometimes granular, at others close, and others earthy. The glassy lavas resemble in every respect the vitreous matter which is produced in our furnaces by the process of melting, they possess a lively lustre, a great degree of brittleness, and in the interior a compact texture, which gives them the resemblance of jellies which have attained a great degree of solidity. The most remarkable of these vitreous lavas is known by the name of *obsidian*.

44. In several accounts of the eruptions of volcanoes, large volumes of water are mentioned as having been ejected. The concurrent opinion of those who live in the vicinity of such mountains, is certainly in favour of such statements, and it is supported by the undoubted fact, that large volumes of water descend round the base

of the volcanoes during their eruption. A most conspicuous instance of this kind is stated to have occurred in 1742, during an eruption of Mount Cotopaxi, in Ecuador, when the water formed a torrent, which filled the low tracts near Quito, to a height of 120 feet, and ran four feet in a second.

Modern philosophers, being firmly convinced that this water is not derived from the bowels of the earth, and not a subterraneous production, account for this phenomenon by having recourse to the effects produced by the ascending currents of air. The air reposing over the crater being strongly heated, rises rapidly upward, and the cool air taking its place is also soon compelled to take the same direction. On arriving at a great elevation it is condensed into a cloud, which soon acquires large dimensions. A further condensation converts the air into water, which then pours down in large streams. This water, in descending, is mixed up with the ashes with which the contiguous portion of the atmosphere is filled. This mixture falls on a country which is already covered with a layer of ashes that prevents the water from penetrating into the soil, or from running off in the usual way. In this manner swamps are formed, which being constantly increased by matter of a similar description, suddenly burst the material forming their boundaries, and inundate large tracts of country. As this commonly happens at places where it has been thought impossible to account for the inundation in any other way, people have jumped to the conclusion that large volumes of water must have been thrown up by the volcano.

The great volumes of water by which the eruptions of the Ecuadorian Andes are attended, are partly of a different origin. The summits of these colossal mountains rise above the snow-line. The most elevated part of them is therefore covered with snow and ice, which in the long intervals between the eruptions accumulate to an astonishing depth. When the subterraneous fire begins to heat the mass of which the cone of the volcano is composed, the bond is loosened by which the snowy covering is attached to its base, and then it rushes down

the steep declivities of the mountains The adjacent country is instantaneously inundated by torrents of water, in which thick masses of ice and snow are mixed up with smoking scoria and hot ashes.

From the volcanoes of the Andes large volumes of water are sometimes disgorged which are filled with fish during their eruptions. Humboldt has explained this phenomenon. He ascertained that the rocks composing the mass of the mountains enclosed on their declivities or at their bases caverns of very large dimensions These caverns are, during the intervals between the eruptions, filled with water, which is derived from the snow lying on the top of the mountains, and descends to the caverns by infiltration Thus in time large subterraneous reservoirs of waters are formed in the interior of the volcanoes The collections of water usually communicate by narrow channels with some of the small rivers and torrents of the table-land. By means of these channels the fish inhabiting the rivers get into the reservoirs, where they multiply in an astonishing manner. When under these circumstances the volcano begins to assume a certain degree of activity, the earthquakes, which always precede the eruptions of the volcanoes of the Andes, forcibly shake the whole mass of the mountain, the subterraneous reservoirs are suddenly thrown open, and there follows an immense rush of water over the adjacent country mixed up with fish and with a matter resembling tufa. When in the night between the 19th and 20th of June, 1698, the summit of Mount Carguairazo was broken down by an eruption, so that only two large horns of the ancient crater remained standing, a liquid consisting of tufa and mud, intermixed with a loam of great sterility, was poured over a surface of about forty square miles, and in these substances a great number of dead fish were found embedded.

45. The *permanently active volcanoes* resemble, in general, the intermittent ones, except that the ejection of scoria and lava is not attended by such violent phenomena. Only a few of these are found on our globe, and they are, as already stated, of a much lower elevation

than the intermittent volcanoes. They can hardly be called mountains. Their permanent activity is ascribed to their moderate elevation The chimney by which the communication between the interior and exterior of the globe is established, being much shorter than in other volcanoes, it is very probable, that in this passage few obstacles occur to the rising of the volcanic matter. Besides, this matter arriving sooner at the orifice of the chimney, is in a greater state of liquidity. These two circumstances must facilitate the overflowing of the lava, and this phenomenon goes on with greater ease, as is proved by the very slight commotions of the ground which accompany it, the very moderate noise, and the total absence of that awful column of smoke and ashes with which all the eruptions of intermittent volcanoes terminate.

Those philosophers who interested themselves particularly in the study of the volcanic phenomena, were of course desirous of obtaining a sight of the manner in which the lava is brought up in the volcanic chimney and ejected from its orifice. The imminent danger to which they would have exposed their lives in approaching close to the orifice of the crater of an intermittent volcano, whilst that extremely tumultuary process is going on which is called an eruption, prevented them from making an attempt of this kind. When, however, it was known that this process was much more regular and less violent in the permanently active volcanoes, they resolved to profit by this circumstance, and to complete their knowledge of the volcanic activity, by observing the eruptions of one of them. For that purpose they chose Mount Stromboli, the only permanently active volcano which is found in Europe The following account of this mountain, and the observations made on the manner in which the subterraneous forces operate in its crater, is taken from the German writer, Hoffmann, who visited the volcano in December 1831, and January 1832.

46. Stromboli is the most northern of the Lipari islands. It lies about seventy miles due north of Mount Etna, and somewhat more than fifty miles north of Capo Bi-

aneo, in Sicily. The island consists of a single mountain, which has a circumference of about nine miles, and whose summit rises to about two thousand nine hundred feet above the sea. This mountain is a volcano which has been constantly active for a time beyond record. Homer has noticed it, and in ancient times it was called the lighthouse of the Tyrrhenian Sea, because a fire is perceived during the night hovering over its summit.

The crater of this volcano, according to Hoffmann, is rent by a chasm which runs across the whole island from south-west to north-east. One half of the cone enclosing the crater has collapsed, and the other half forms a semi-circular enclosure. The sides of this semi-circular ridge are very steep, especially towards the crater, where they are apparently only composed of accumulated volcanic matter This circumstance enables the observer to notice from a well-chosen point on this ridge all that is going on in the crater, which is depressed from five to six hundred feet below the highest part of the mountain. It appears that the openings in the crater are subject to changes in their situation and number. When the German naturalist visited the place, he found three openings in the bottom of the crater The central opening was evidently the principal orifice of the volcano. It was more than two hundred feet in diameter, and did not present anything which deserves particular notice. Columns of vapour rose from it slowly and with great regularity, and the sides of its orifice were covered with numerous incrustations of sulphur of a deep yellow colour.

At no great distance from this opening was another. It was near the place on which the observer had placed himself, was somewhat more elevated than the great opening, but was only twenty feet in diameter In this opening Hoffmann observed for a length of time the column of liquid lava alternately rising and sinking. It frequently rose to its very top. The melted matter did not answer the idea he had formed by reading the accounts of eruptions. He had expected to find a burning mass covered with flames, rising above the orifice. But there were no flames. It was a mass, shining with

great brightness, and he compares it with the appearance of melted metals, for instance, with iron, running from a furnace in which it has been melted for casting, or with a mass of glass in a glowing fire. Spallanzani gives a similar description, and both agree with the account given of the lava by Sir William Hamilton, who, in 1766, had an opportunity of observing the matter at a place not far from the opening from which it had issued

In looking attentively at the motion of this mass in the opening, Hoffmann was soon aware that it was subject to some variation In general the column of fiery liquid remained about twenty or thirty feet below the orifice It was evident that it maintained that position only by being supported by the expansion of the volumes of steam confined below, for its surface moved up and down very uniformly and in regular intervals of one second's duration. Though the difference of level produced by these motions was not large, it proved evidently that the pressure originating in the gravity of the mass was constantly met by the force which the ascending vapour exercised on it During these motions a peculiar noise was heard, which the observer compared to the popping noise produced by a current of air rushing through the opening in the inner door of a blast-furnace Every time the column of lava was raised in the chimney, a ball of white vapour, well determined and rounded, was seen emerging from the surface of the melted matter As soon as the vapour had escaped the column sank again. The vapour at every escape regularly detached from the surface of the mass some small pieces of lava, which were carried out of the chimney and thrown over its orifice, which at night added greatly to the picturesque beauty of the scene

This was the common action, but from time to time, and mostly at intervals of a quarter of an hour, this process was interrupted, occasionally several times in succession, by a more active paroxysm of the volcanic powers. The column of lava, after having ascended higher than usual, was then suddenly arrested, the vo-

lume of smoke which had escaped from it, did not rise, but remained fixed; sometimes it seemed as if the smoke was again descending into the mass At the same instant the observer felt a more or less violent concussion of the ground on which he was standing, and observed a perceptible wavering in the sides of the crater It was evidently a slight shock of an earthquake, and it was immediately succeeded by a dull rumbling noise proceeding from the opening Almost at the same moment a large volume of vapour rose from its orifice with a shrill sounding crash This cloud carried off a whole layer from the surface of the melted matter, having broken it previously into numberless pieces An intense degree of heat must have been evolved, as it was sensibly felt by the observer, though standing at a considerable elevation above the spot The pieces of lava rose in divergent lines as they were carried upward, so as to form a girandole, and descended on the contiguous places like a shower of fire Some pieces rose to an elevation of apparently more than one thousand two hundred feet, and passed over the head of the looker-on in a wide arc. When such a paroxysm had terminated, no lava was visible in the opening, it appeared to have disappeared entirely. But it soon became evident that this momentary state of quiescence was the effect of the column of lava having retired lower than before into the chimney After a few minutes the shining matter again made its appearance in the orifice By degrees it rose to its former level, and the usual state of the volcano was re-established

This account of the German naturalist agrees with that of Spallanzani, but the Italian had an opportunity of observing another remarkable fact. One night, whilst he was watching the operations in the crater, the lava sank down without immediately rising again The light, produced by the reflection of the red-hot matter which had previously illuminated all the objects within the crater, had scarcely disappeared, when numberless small columns of vapours made their appearance. They rose from the edges of the orifice and from the declivities and

sides of the crater. Their emerging from the ground was attended with a hissing noise, which Spallanzani compares to the rustling noise produced by the bellows of a furnace. This continued for several minutes, and the sulphureous vapours rising from the steep declivity near him began to be very troublesome, when the burning mass suddenly rose from below, and shortly afterwards the volcanic process assumed its regular course Spallanzani explains this phenomenon by supposing that whenever, by some accident, the consistency of the lava on the surface is so incrusted as to prevent the vapour from escaping through the mass, these vapours find their way out through the narrow rents in the sides of the mountain. As soon, however, as the lava has re-acquired a greater degree of liquidity, from the condensed heat, the vapours are again able to break through the mass and to escape. The process then re-assumes its regular course.

The third opening which Hoffmann observed in the crater of Mount Stromboli was more than one hundred feet lower than that in which he had observed the volcanic process going on in such a remarkable way. This third opening slowly and uniformly discharged a moderate quantity of red-hot lava, which ran down the declivities of the mountain in a narrow stream. Hoffmann considered it as only a lateral branch of the volcanic chimney, which terminated within the wide orifice, and thinks that the column of lava, whilst it rises and sinks in the large chimney, continually presses a portion of the melted matter into the lateral pipe, and that, in this way, a constant discharge of red-hot lava is maintained

47. This account of the volcanic process in the crater of Mount Stromboli conveys to us an idea of the manner in which the same process operates in the intermittent volcanoes. There is certainly a great similarity between the permanently active volcano of Stromboli and the last-mentioned class of volcanoes. But the volcanoes which are constantly active assume in some instances a character so different in many particulars, that they can hardly be all comprehended under the same description. On that account we insert a short notice of two of them, of Mount

Kraabla in Iceland, and of the volcano of Kirauea in Hawaii, one of the Sandwich islands.

The bottom of Mount Kraabla is occupied by a circular pool of black water at least three hundred feet in circumference, from the middle of which a vast column of the same liquid is ejected, accompanied with a loud thundering noise and thick clouds of vapour and smoke. The surface of this pool may be about seven hundred feet below the highest part of the rim of the crater. Henderson describes the volcanic process in this pool in the following words:—

"Nearly about the centre of the pool is the aperture whence a vast body of water, sulphur, and bluish black bolus is thrown up, and which is at least ten feet in diameter. The height of the jets varied greatly, rising on the first propulsions of the liquid to about twelve feet, and continuing to ascend, as it were, by leaps, till they gained the highest point of elevation, which was upwards of thirty feet, when they again abated much more rapidly than they rose, and, after the spouting had ceased, the situation of the aperture was rendered visible only by a gentle ebullition which distinguished it from the general surface of the pool. During my stay, which was upwards of an hour, the eruptions took place every five minutes, and lasted about two minutes and a half. I was always apprised of the approach of an eruption by a small jet that broke forth from a pool a little to the east of the great one, and which was evidently connected with it, as there was a continual bubbling in a direct line between them. None of its jets exceeded twelve feet, and generally they were not above five. Another bubbling channel ran a little way to the north-west of the principal opening, but did not terminate in a jet like the former. While the eruption continued a number of fine silver waves was thrown round to the sides of the pool, which was lined with a dark blue bolus, left there on the subsidence of the waves. At the foot of the bank on which we stood were numerous small holes, whence a quantity of steam was unremittingly making its escape with a loud hissing noise; and on the

west side of the pool was a gentle declivity, where the water ran out, and was conveyed through a long winding gully to the foot of the mountain"

48 It would seem that at no place is the communication between the interior and exterior of the globe so complete as on the Island of Hawaii, in the volcano of Kirauea, which must therefore be considered as the most remarkable of the volcanoes of the earth, and which doubtless will furnish us with a number of new facts, when its operations shall have been studied with the same attention and for such a length of time as those of Mount Vesuvius. It differs from other volcanoes in aspect, shape, and in the manner in which the ejected lava is disposed of

The volcano of Kirauea is not found on the summit of a cone-shaped mountain, but in a depression which is more than a thousand feet below the level of the adjacent country, but which is still 3873 feet above the sea. The circumference of this depression, according to the estimate, is between fifteen and sixteen miles. The sides of it are steep, at some places nearly perpendicular, to a depth of more than seven hundred feet, where they terminate in a ledge or plain They are composed of volcanic matter, apparently a light red or grey kind of lava, vesicular, and lying in horizontal strata varying in thickness from one to forty feet The ledge or plain at the base of this declivity consists of solid black lava, it is of irregular breadth, but completely surrounds the whole depression. Beneath this ledge the sides slope gradually towards the bottom of the crater, until they terminate at a second ledge, the perpendicular height of this slope is about three hundred and sixty feet, it consists of grey lava, which has assumed at some parts a white colour from having been blanched by vapours. From this ledge to the bottom of the crater the descent is only forty-three feet

The bottom of the crater at its lowest part is about three miles long from north-west to south-east, and nearly a mile wide? It contains two volcanic laboratories, an active and an extinct one The first is called Great Kirauea, and the second Little Kirauea. They are di-

vided from each other by a ridge of lava, level at its top, and about three hundred and seventy yards wide.

The depression called Great Kirauea, in which the activity of the volcano is concentrated, is about two miles long Its bottom is covered with solid lava, except that a part of it is occupied by two lakes of liquid lava. The smaller one, situated towards the north, forms a circular basin three hundred and nineteen yards in diameter, the larger lake, near the south-west extremity, is eleven hundred and ninety yards long, of a heart-shape, and a breadth between the lobes of about two hundred yards. Fifty-one conical islands, varying in size and containing as many craters, rise either from the edge or from the surface of the lakes Twenty-one of them constantly emit columns of grey smoke, and several of them continually vomit streams of lava from their fiery mouths, which roll in burning torrents down their outsides into the boiling mass below A number of small craters in vigorous action are situated on the declivities with which the depression is surrounded. The streams of lava which they emit also roll into the lakes and mingle with the burning mass below. In this manner the two lakes are constantly supplied with the melted fluid.

The smaller lake is in a continual state of ebullition. The larger appears at times quiescent, with serpentine fiery streaks on its surface, but at other times the lava is thrown up to a fearful height Shortly after the numerous vent-holes have discharged their steam or slag, the lake for a short time becomes tranquil. Both lakes have a steady southerly current, the force of which Mr. Douglas was enabled to determine accurately by throwing blocks of lava on the stream, and noticing the time they took to pass a hundred yards, it is at the rate of three miles and nearly a quarter per hour The south end of both lakes presents one of the most magnificent spectacles in nature—a vast cauldron of lava in furious ebullition, sometimes spouting up to the height of twenty to seventy feet, rolling and tumbling in fiery waves, hurrying along and finally precipitated down an elliptical fiery arch. The arch of the smaller lake, as stated

by Mr. Douglas, has a width of a hundred and forty-two yards, with a maximum height of forty-three feet In this awful arch the force of the lava is in some degree arrested by the escape of the gases or volcanic vapours, and large blocks are thrown back. Some of them are literally spun into a filamentous glass, which is carried by the wind all around the volcano. The sound issuing at the same time from the archway is beyond all comparison, that of all the steam-engines of the world, says Mr. Douglas, would be a whisper to it.

On the lower ledge surrounding the crater is a tract five miles square, which seems to have been recently in a state of igneous fusion. In the process of cooling the lava has apparently been broken up into immense ledges and rolled masses, like the breaking up of a great river of ice These masses of lava are of every shape and form, from gigantic coils like enormous cables to threads as fine as human hair, which are carried by the wind a distance of many miles On this tract are also dispersed numerous chimneys of various shapes, some of which emit scoria, smoke, or steam, while others are comparatively tranquil. Among them are three cones or bluffs of from twenty to twenty-five feet in height, and about one hundred and twenty yards in breadth at the base, with lateral doors, similar to those of a baker's oven, and into those, by kneeling on the edge, it is possible to peep and to witness a terrific vacuity and a red-hot atmosphere, while the volcanic vapour is at the same time discharged by a terminal vent-hole.

The burning matter appears to be discharged from the lakes into the bowels of the earth, but it has a subterraneous outlet into the sea, in lat 19° 11′ 51″ N. The place is called in the native language Punahala, or "broken in." Near its vicinity many overflowings have taken place over a space of fourteen miles in length; in some of the steep chasms seventeen layers of lava may be counted The whole eastern coast of Hawaii, through the district of Puna, is one entire sheet of lava.

The depression called Little Kirauea is of much smaller dimensions; it approaches more to a circular form. Its

bottom is occupied by solid lava, which, however, does not appear to be everywhere quite cold. But it must have been long in a state of repose, for the declivities of the depression, which have a very gentle slope, are overgrown with bushes and trees. Among the trees some occur which have a hundred and twenty concentric rings or annual layers of timber. On the neck between the two depressions the ground opened in 1832 and discharged liquid lava for a period of three days into both depressions, this eruption was preceded by slight earthquakes

49. As one of the most remarkable natural events, it might be remarked that volcanic eruptions sometimes occur which do not originate in volcanoes, and even in places where no volcanoes exist These phenomena may therefore be called *irregular volcanic eruptions* Such eruptions have taken place in level and low countries, as well as in mountain-tracts. In 1783 an extensive mountain-mass in Iceland, called the Skaptaar Yokul, where no volcanic phenomena had been previously observed, was suddenly laid open by the subterraneous force, and the lava issuing from it deluged the adjacent country. A similar event occurred in the island of Lanzarote, one of the Canaries, in 1730. The manner in which these eruptions were effected appears to bear a close resemblance to the opening of the lateral rents in the intermittent volcanoes The surface of the country is broken open by the elastic vapours underground, and thus a wide rent is formed, from which the volcanic matter is ejected. As, however, the rent is of irregular width, the subterraneous fluids direct their force in preference to those points where it is widest, and at such places cones of eruption are soon formed by the accumulation of scoria and other substances brought up by the elastic vapours. After some time, probably when some obstacle has arisen in the cone of eruption, the subterraneous forces widen the rent at some other place, and a new cone of eruption is formed. Thus it goes on until the elastic vapours cease to be active. These rents, however, are in general much more exten-

sive than those formed by intermittent volcanoes. Sometimes they exceed ten miles in length, and have a great number of cones of eruption, as was the case in the two eruptions just mentioned On the rent in the Skaptaar Yokul more than twenty cones of eruption are found; and, during the eruption in Lanzarote, twelve large ones were formed, besides a great number of smaller ones, situated close to the larger ones, and which are probably only their branches.

The island of Lanzarote is very remarkable in this respect. One irregular eruption occurred in 1730, and another in 1824 The last eruption, however, did not occur at the same place where the rent had been formed in 1730 This is very remarkable, when it is considered that both rents run in the same direction from east to west, and that they can hardly be more than two or three miles from one another It will be asked, of course, why did the earth not break open at the same place? Perhaps an observation made by Mr Poulet Scrope respecting the lateral eruptions of intermittent volcanoes may account for this remarkable circumstance. This gentleman says that perhaps a new lateral rent is never formed in a volcano at a place where the mountain has been laid open before, and he thinks that the weak part of the mountain which has once given way, has been strengthened by the lava which entered the rent, and there solidified In this manner it has acquired a firmness better able to resist the pressure of the lava within the chimney than those parts of the mountain which have not been previously split. This observation appears to be very just, and to afford a satisfactory explanation for the facts stated respecting the two eruptions in Lanzarote.

50 The phenomena attending eruptions of this kind do not materially differ from those which accompany the eruptions of intermittent volcanoes, except that they are on a much larger scale, more impressive, and more terrific, and that sometimes they continue for a great length of time. The eruption in Lanzarote in 1730 lasted for more than five years and a half, beginning on the 1st of

September, 1730, and terminating on the 16th of April, 1736, so that the inhabitants of the island were compelled to emigrate and to take refuge on the island of Gran Canaria. It is astonishing what immense masses of lava are emitted by these extraordinary phenomena. Sometimes they are spread over a hundred square miles and more There are on the surface of our globe several places where immense tracts of country are covered with enormously thick layers of lava, without its being possible to discover whence the matter has issued. Philosophers find it, therefore, impossible to account for the origin of such lava One of the most extensive fields of lava occurs in Patagonia, on both sides the river of Santa Cruz. It extends from the base of the Andes eastward over more than half the width of the continent, overspreading in that direction a country of more than a hundred miles in extent, while it has not yet been ascertained how far it reaches to the north and south. This immense layer varies in depth from a hundred to three hundred feet As at present no active volcano exists in that latitude, within the range of the Andes, its origin remains in obscurity. It is probable that, at some remote period, an irregular volcanic eruption has taken place, either in the mountain-chain itself, or along its base, and that this immense mass of lava has flowed from a rent of unusual dimensions.

51. It is a fortunate circumstance that these terrible phenomena are of rare occurrence, for they must be numbered among the most destructive operations of nature. All the active volcanoes in the world during a whole century do not cause as much damage as is sometimes produced by one of these events, the reason is obvious The volcanoes and the effects of their eruptions are known in the countries in which they are found, and they are, besides, usually surrounded by at least a tract of some extent, unfit for cultivation. The streams of lava issuing from their tops or sides do not always extend to those parts which are cultivated, and then they do no damage at all. Whenever they reach the cultivated grounds they usually overrun only a few acres of land,

or in some rare cases a square mile; but it is different with the irregular volcanic eruptions They occur in places where no volcanoes are found, and commonly break out in the midst of a cultivated country, which is then overflowed by the lava to an immense extent Tracts of many square miles are thus converted into useless wastes, and a large number of families are deprived of their property, their means of subsistence, and their homes The loss of life is not generally great, but all other kinds of damage they cause are far more serious than those effected by earthquakes, and continue to be felt much longer, for the lava which has overrun countries which had previously attained some degree of cultivation, must in most cases be exposed for centuries to the effects of the atmosphere before it undergoes such changes as render it again available for cultivation The lava which in 1730 was ejected on the island of Lanzarote, covers a third of the island, or a space of more than a hundred square miles Several flourishing and populous villages were formerly dispersed over that district More than a hundred years have elapsed since the change was effected, and the whole tract is still a stony desert, on which no plants grow, and no animal finds subsistence, and in this state it may still continue for many centuries to come

52 There is no record in history of any irregular volcanic eruption having taken place on the continent of Europe, but considering that in many places, as in the south of France, and in the countries bordering the Rhine, large tracts of country are covered with layers of lava, we may presume that such events have occurred before the historical period commenced No part of the globe appears to be more frequently visited by these destructive catastrophes than the Azores, or Western Islands Though four centuries have not yet passed since these islands were taken possession of by the Portuguese, the number of recorded eruptions of this description exceeds twelve Most of them have occurred in the islands of St Michael and St George, and in both have proved very destructive. The Canaries

have also frequently been subjected to them, especially Lanzarote. It appears also that many of the eruptions noticed in the history of Iceland have been of this description. This is certainly the case respecting the eruption of the Skaptaar Yokul, which occurred in 1783. As this is one of the most remarkable events recorded in the natural history of our globe, the following account of this eruption will probably be acceptable, even if considered only as a specimen of the nature of these eruptions.

53. The Skaptaar Yokul, or Snow-mountain, for this is implied by the Icelandic term Yokul, is a mountain-mass running from south-west to north-east, always surmounted with snow, and at its eastern extremity connected with other snow-mountains. It lies about forty miles from the nearest sea. It was on the southern declivity, or that which faces the sea, that the earth opened in 1783. It appears that the rent formed during the eruption was about fifteen miles in length; for along such a space a number of conical hills, or craters of eruption, are still found, whose number probably falls not much short of thirty. On the declivity where the rent opened, two rather large rivers take their source, which fall into the sea at places about ten miles distant from each other. The western is called Skapta, and the eastern Kverfisfliot. By following the channels of these two rivers, the melted matter reached the low country which lies between the mountain and the sea. None of the Icelandic annals make mention of any eruption having previously occurred in these places.

The eruption was ushered in by earthquakes, which succeeded one another for eight days, from the 1st to the 8th of June; and which increased in violence. On the morning of the 8th a prodigious cloud of dense smoke darkened the atmosphere, and was observed to be continually augmented by fresh columns rising from behind a range of low hills, which hid the place of the eruption from the inhabitants of the plain; they soon, however, discovered that a tract of country in their vicinity was completely covered with ashes and other volcanic matter. The eruption had commenced, but as

the opening in the ground was probably not large enough to give a vent to all the elastic vapours underground which were striving to escape, the concussions of the earthquake continued to shake the country with great violence, and were accompanied by loud subterraneous reports, while the air began to be filled with vapour and gases, so charged with electricity as to produce unintermitting flashes of lightning, attended with the most tremendous peals of thunder Meanwhile, the heat by which the eruption was attended had begun to melt the ice on the nearest part of the Yokul, and as the waters of the river were greatly increased by the access of fresh volumes from under the ice, they overflowed the adjacent countries.

On the 10th the fire first became visible. Vast fire-spouts were seen rushing up amidst volumes of thick smoke The lava had issued from the openings and entered a glen, by which it ran to the valley of the Skapta river When it reached the bed of this river a violent contention between the two elements ensued, attended by development of an amazing quantity of steam, which may easily be imagined, when it is stated that the river was dried up, and that the lava filled its bed in the space of twenty-four hours. The river runs between high rocks at this part, which rise to between four and six hundred feet above its level, and enclose a valley about two hundred feet wide The lava not only filled up this valley, but overflowed to a considerable extent also the fields which were on the higher grounds. Several farms and hamlets were destroyed, and their pasture-grounds and meadows buried for ever under the lava In the meantime the thunder, lightning, and subterraneous concussions were continued, with little or no intermission. and besides the splittings of the rocks and earth which the lava burnt in its progress, the ears of the inhabitants were stunned by a tremendous roar proceeding from the volcanic orifices, which resembled that of a large cauldron in the most violent state of ebullition, or the noise of innumerable bellows blowing with all their might into the same furnace.

Having filled up the valley of the Skapta river, the stream of lava reached the plain, there its progress was for some time arrested by an immense abyss in the bed of the river, into which it rushed with a great noise. In filling this cavity the lava had partly cooled, but an immense supply of new material overlaid the mass which had already cooled, rose to a prodigious height, and precipitating itself over it, at length proceeded southwards across the plain. Having buried a considerable portion of the plain, by which several farms and hamlets were destroyed, it rushed into some subterraneous caverns, and, during its progress under ground, threw up the crust either on one side or to a great height in the air. Where it proceeded below a thick indurated crust, where there was no vent for the steam which escaped from the lava, the upper covering of the crust was broken to pieces and thrown up with the utmost violence and noise to a height of nearly one hundred and eighty feet

On the 18th another dreadful ejection of liquid and red-hot lava issued from the openings During its progress through the channel of the Skapta it covered even the rocks on its sides which had towered above the reach of the former floods, and flowed down with amazing velocity and force over the masses that were cooling, so that the one stream was literally heaped over the other. In many places large pools of water had been formed near the lava which had filled up the channel of the river on the first discharge. The new burning stream reached them, put them into a violent state of ebullition, and caused them to overflow the adjacent country, by which several farms were destroyed.

After having been re-inforced by this supply, the melted matter continued to flow with considerable velocity over the plain, where it soon divided into two branches, of which one ran to the east and the other to the west, each of them destroyed several farms which stood in their way. It would, probably, have soon stopped, had not several new eruptions taken place between the 24th of June and the 13th of July, which

sent forth such immense masses of burning fluid that they raised by several feet the layers formed by the former discharges, and were still sufficient to extend their devastations over countries containing many square miles which had not been reached by the last stream When the lava on the 20th of July at last ceased, it was found that nearly the whole country between the Skapta and Kudafliot rivers, whose beds are about twenty miles distant from each other, had been almost entirely converted into a stony desert, and in this state it still remains The length of this immense sheet of lava, from the place where it issued from the volcanic orifices to its termination on the banks of the Kudafliot and the vicinity of the sea, is probably not less than fifty miles, and its greatest breadth in the low plain between twelve and fifteen miles The height of the masses of lava in the level country does not exceed a hundred feet, but in some parts of the Skapta channel it is not less than six hundred feet It may be questioned whether all the lava which has flowed from Mount Etna and Mount Vesuvius within historical period, would, if put together, form such a volume as that which by the irregular volcanic eruption of the Skaptaar Yokul was ejected, and ran down the channel of the Skapta river in twenty-five days

But even the ejection of these enormous masses of lava had not yet sufficiently disburdened the bowels of the earth By the efforts of the subterraneous forces the volcanic rent was continued farther to the east by a new splitting, and from these places, which were some miles east from the cones of eruption formed in June, a quantity of lava was discharged which laid waste the Valley of the Kverfisfliot and the contiguous plain The day on which this eruption commenced is not stated, but on the third of August the inhabitants were informed of its having taken place by the same phenomenon which had been observed at the beginning of the previous eruption. An immense quantity of steam rose from the Kverfisfliot, and the heat which the water acquired in a short time, showed clearly that the bed of the river had been

entered near its source by the hot melted matter. In a short time the channel of the river was dried up, but its empty bed was soon filled with running lava to the very brink, and the low grounds were inundated on both sides by the volcanic mass On the ninth of August it had already reached the point where the valley opens into the plain, then it appears that the velocity of the stream was greatly increased, for in the course of a few hours it had spread itself across the plain to a distance of nearly six miles. Its progress was slower afterwards, but as it received one or two considerable supplies of melted matter from the source, it continued to extend over the low country to the end of August, when it ceased, after having overrun a great part of the district. The mass of lava which by this eruption was poured into the valley of Kverfisfliot and the adjacent plain is about forty miles in length, and seven in width where it is broadest.

54 It has been frequently observed as a remarkable fact, that all the volcanoes of our globe are situated either on islands or on countries bordering on or at no great distances from the sea This fact gained a strong support from the opinions of those philosophers who endeavoured to explain the origin of volcanoes by a theory, in which the internal conflagration of the globe was supposed to be partly dependent on the accession of water But Humboldt, rejecting this theory, explains the fact in a more satisfactory way. He says that in the countries adjoining the sea, their surface in general is comparatively much less elevated above its level than in those which are placed at great distances from it in he centre of a large continent. From this fact he infers, that in such countries, the solid crust of the globe is much thinner than in those which lie far off from the great basins of the ocean, and that consequently the subterraneous forces, when trying to open a vent for their escape, find less resistance there than in the centre of a large compact mass of land. This is the reason why by far the greater number of the vent-holes of the internal conflagration are found in the vicinity of the sea.

At the same time he has pointed out, that, according to the expressive and circumstantial accounts of the Chinese geographers, a volcanic region of great extent is found nearly in the centre of Asia remote from the ocean.

Some pains have been taken to ascertain the number of active volcanoes which are found on the globe It is, however, difficult to obtain an exact result, as some are mentioned by one traveller as being extinct, while another may enumerate them among the still active volcanoes This difference of opinion is easily accounted for when we remember that a great number of the intermittent volcanoes enjoy such long periods of repose that a century may pass between two eruptions Besides, it sometimes happens that a volcano which has been extinct for centuries re-assumes its activity It must be also observed that some parts of the globe have not yet been visited by attentive and well-informed observers, and that for the accounts of the volcanoes existing in such unexplored regions, we are obliged to rely on the narratives of unscientific reporters The following statement of them is therefore only to be considered as an approximation to the truth, and one which is probably considerably below the actual number

The number of active volcanoes thus estimated is about three hundred and twelve. By far the largest proportion is found in or around the Pacific Ocean In the countries bordering on that great oceanic basin, and on the islands dotting its bosom, not less than two hundred and thirty-one are found, consequently more than three-fourths of the whole existing number The number of active volcanoes in that series of islands which, under the name of the Sunda Islands, stretch across the Indian Ocean, is also large, for they contain sixty-five In the Atlantic and the countries bordering on them only a few are found, not more than fourteen , and in the centre of Asia, in the Thian-shan mountains, only two

55. The Pacific Ocean is, as it were, enclosed by a girdle of volcanoes. At many places several of them lie close together, so as to form a group, but the groups

themselves are separated from each other by tracts of country sometimes a thousand miles in extent, in which no active volcanoes are met with But as all of them are near the shores of the sea, either on the continent or on islands, it is evident that nature in arranging them has followed a certain order and law, which cannot be overlooked. It is, however, remarkable that on its eastern side, where the ocean washes the shores of America, the volcanoes are all situated on the continent, and with few exceptions are raised on the summit of large and elevated mountain-masses, whilst on its western side, where it is confined by Asia and its islands, and by Australia, none of the volcanoes, with the exception of those of Kamtschatka, which peninsula may almost be considered as an island, are situated on the continent, but on islands situated at a moderate distance only from the shores of the continent In the islands the volcanoes are not placed on large mountain-masses, but rise singly either from low plains or on a base of moderate elevation

In surveying the volcanoes surrounding the Pacific we begin with the southern extremity of America. Tierra del Fuego does not appear to contain an active volcano, though it is probable that it has received its name from the supposition that a mountain ejecting fire really existed. The most southern of the South American volcanoes appears to be St. Clemente, near 44° N. lat With it begins that series of volcanoes which is called the Chilian Group, and which extends to nearly 30° N lat or about fifteen degrees of latitude. It contains at least sixteen active volcanoes placed on the top or at the base of the Andes.

This group is divided from the next group, called the Bolivian, by a space of ten degrees of latitude in extent, in which no active volcanoes occur. The Bolivian Group contains six or eight active volcanoes, which are dispersed over a very elevated table-land, called the Table-land of Titicaca; they lie between 21° and 15° S. lat.

This group is divided from the Ecuadorian Group by a space of thirteen degrees of latitude. The most

southern volcano of the Ecuadorian Group, Mount Sangay, is situated south of 2° S lat. This group extends to 5° N lat. The volcanoes are placed on an elevated table-land, that of Quito, and Humboldt is of opinion, that under this mass Nature has placed an enormous furnace, from which the fire breaks out sometimes at one point and sometimes at another Most of the volcanoes belonging to this group are placed on both sides of the table-land Their number amounts to eighteen.

Passing over the isthmus of Panama, where no volcanoes are found, we arrive at that group in which the volcanic powers appear to be most active on the American Continent This group, the central American, extends over more than ten degrees of longitude, and contains probably more than thirty-eight volcanoes. Though most of them are placed on a table-land, the mountain-masses on which they rise are much less elevated than those in the Andes of South America. This is probably the cause why the volcanoes of Central America are more frequently subject to eruptions, than the other volcanoes of the American continent In this group is one volcano, which is in continual activity, Mount Izalco, not far from the town of Zonzonate.

The volcanoes of Mexico are hardly more than two hundred miles distant from the Central American group. They are six in number, and lie on a line which runs across the American continent from east to west, a little south of 20° N. lat One of the volcanoes of this group is the Jorullo, which was formed by an eruption in 1759, and of which we have given an account.

No active volcano occurs on the western coast of America north of 20° N lat. until the mouth of the Columbia river is passed, on the banks of which a single and isolated volcano, Mount St. Helens, is found. Farther north, near 56° N. lat, is another single volcano, Mount Edgcumbe, situated on an island not far from the Russian colony of New Arkhangel.

The most volcanic region on the globe is situated at the northern extremity of the Pacific. It extends be-

...een America and Asia, comprehending the peninsulas Aliaska and Kamtschatka and that series of islands ...h lies between them and is known as the Aleutes. ... this region, which lies between 50° and 60° N. lat. ...t less than fifty-seven active volcanoes have been ...rtained to exist, namely, four on Aliaska, thirty-two ... the Aleutes, and twenty-one in Kamtschatka It ...pears that the volcanic agency in this region is more ...ve than anywhere else on the globe, as frequent ...es in the form of the volcanic islands are observed ...even new ones formed

In proceeding southward from the most southern extremity of the peninsula of Kamtschatka the activity appears to decrease, though not rapidly In the islands ...ed the Kuriles, which occupy more than five degrees ... latitude, twelve active volcanoes are found, and in ... large islands which constitute the empire of Japan, ...d extend over fifteen degrees of latitude, their number probably does not fall short of eighteen All the islands ...st mentioned constitute, as it were, one chain, as they ...e not interrupted by any large portion of the sea, and ... the peninsula of Kamtschatka is added, which may be ...sidered as the northern prolongation of the chain, the ...canic barrier which in these parts fringes the continent ... Asia extends almost without interruption over thirty degrees of latitude, and contains fifty-one active volcanic ...ifices some appear to be incessantly active.

Between the southern extremity of the Japanese island of Kiusiu and the Philippines is a wide break in the line which extends over more than ten degrees of latitude (from 30° to 20° N), and in this the island of Formosa and a few smaller ones lie. On the large island probably three active volcanoes exist, and on the smaller two

From the peninsula of Kamtschatka to Formosa the direction of the volcanic islands is from north-east to south-west, but farther south it runs first southward and then to the south-east through the Philippines and Moluccas. In this part of the line the volcanic power ...s again to increase in activity, as in the large

archipelago of the Philippines the number of active volcanoes amounts to nineteen, and in the smaller one of the Moluccas to nine Both groups taken together comprehend twenty degrees of latitude, and reach beyond the equator

The volcanic line just noticed, beginning with Kamtschatka and terminating near the equator, constitutes the boundary-line of the Pacific along the shores of Asia. Another volcanic line separates the continent of Australia, including the large island of New Guinea, from the same ocean. As this continent extends farther to the east than Asia, the line runs from the Moluccas eastward along the northern shores of New Guinea to New Britain, the Solomon Islands, and the archipelago of Santa Cruz In this portion of the line seven active volcanoes have been noticed. From the archipelago of Santa Cruz the line turns south by east, and passes through the New Hebrides, where two volcanoes in full activity have been seen Between the New Hebrides and New Zealand is a space of fifteen degrees of latitude, in which only a single island with a volcano is met with, but the northern island of the New Zealand group contains three active volcanoes Here the volcanic chain enclosing the Pacific on the west terminates, nearly in the same parallel as the continent of Australia But it deserves to be noticed that in the direction of this line an active volcano was found on the newly discovered antarctic continent by Captain Ross, who called it Erebus. It lies in 77° 32′ S lat. and 167° E long, and no other volcano is known to approach so near to either of the poles

Besides the great number of volcanoes found in the lines which enclose the Pacific on the east, north, and west, a few volcanic groups of islands, with a still smaller number of active volcanoes, are dispersed over its surface. The volcanic groups are the Friendly Islands, the Society Islands, the Marquesas, the Galapagos, the Sandwich Islands, and the Ladrones or Marianas. Active volcanoes are found in the Friendly Islands, the Galapagos, the Sandwich Islands, and the Ladrones. Galapagos are so entirely volcanic, that Mr. Darwin

does not hesitate to affirm that there must be in this archipelago at least two thousand craters, but it is not known how many of them are active at present In the island of Hawaii, belonging to the group of the Sandwich Islands, is that most remarkable volcano, called Kirauea, of which we have given a description

56. The volcanic region in the Indian Ocean extends from east to west. At its eastern extremity it is connected with the group of the Moluccas It commences here in the meridian of the island of Timorlant, and extends westward to the straits of Sunda, a distance of nearly twenty-eight degrees of longitude, or 1900 statute miles It is, however, of inconsiderable width, as nearly all the volcanoes are placed between 7° and 9° S. lat. From the straits of Java it extends north-west, comprehending the south-western parts of the island of Sumatra. The last member of this long chain is Barren Island in the Bay of Bengal, which lies not far off from Sumatra. In this series the volcanic forces appear to be as active as in the region at the northern extremity of the Pacific, more especially so in the island of Java, which is about the centre, where not less than thirty active volcanoes exist. In no part of the globe are the eruptions so frequent and so terrific They appear also to be attended by some phenomena which materially differ from those observed at the eruptions of volcanoes of Europe and America, but the exact nature of these phenomena has not yet been well ascertained These observations apply especially to the volcano of Galung Gung, in Java, in which an eruption took place in 1822, considered as one of the most remarkable recorded in history.

When the geographical situation of this chain of volcanoes is considered as connected with the before-noticed chain which extends from the Moluccas northwards to the island of Formosa, we find that that part of the Indian Ocean which goes by the name of the Chinese Sea is surrounded on three sides by a girdle of volcanoes in the form of a sack The number of active volcanoes found in this remarkable girdle probably does not fall short of a hundred, of which, however, only sixty-four belong to the chain just noticed.

In that portion of the Indian Sea which lies between Hindostan and the western coast of Africa a single volcano is found in the island of Bourbon.

57. The volcanic regions which are situated within the basin of the Atlantic Ocean do not form, like those of the Pacific, extensive chains or series of volcanoes, but are disjoined and placed at great distances from each other. They are four in number—the Italian, the Icelandic, the Atlantic Proper, and the West Indian region.

The Italian region comprehends the north-eastern portion of Sicily, with Mount Etna, the Lipari Islands, and Mount Vesuvius with the Campi Phlegræi. There are three active volcanoes within its precincts. Mount Etna, whose base is about ninety miles in circumference, and which rises to more than ten thousand feet above the sea-level, has always been an active volcano, as far as the records of history can be traced. Before our era only those eruptions were noticed by historians which proved very destructive to the country in its vicinity. Their number amounts to eleven. During the middle ages many of its eruptions have also passed unnoticed, but those of the last three centuries have been carefully noticed. The eruptions of this volcano recorded since the commencement of our era amount to more than sixty. On the Lipari Islands is the semi-extinct volcano of Volcano, and the permanently active volcano of Stromboli, both of which have been noticed before. Mount Vesuvius, which at the commencement of our era was considered as an extinct volcano, and which was not known to have ever had an eruption, broke up in 79 after Christ, and since that time it has been very active, as the number of its eruptions, as far as they have been recorded, amounts to more than seventy-five. The Campi Phlegræi lie to the west of this volcano, and contain several extinct volcanoes, together with one which is semi-extinct, the solfatara of Puzzuoli. On the island of Ischia, which is included in this region, is a mountain which by its white colour announces itself as a volcano. It is called Mount Epomeo, and had an eruption in 1301.

The Icelandic volcanic region comprehends the island of Iceland and the small island of Jan Meyen. The interior of the island of Iceland is a table-land, from two thousand to seven thousand feet above the sea In the eastern districts of the island this table-land comes close up to the sea, and in that part it does not appear that the island has ever experienced any volcanic eruptions. But on all the three other sides there occurs a low tract, intervening between the sea and the table-land, and this tract exhibits at numerous places large sheets of lava of different ages As far, however, as the records of history go, eruptions have occurred at thirty different places. By far the greater number of these eruptions had the character of irregular volcanic eruptions The surface of the earth opened, threw up enormous masses of lava, and closed again At a few places, however, eruptions have repeatedly taken place, and regular volcanoes have been formed, but their number probably does not exceed six The most remarkable are Hecla, on the southern coast of the island, of which during a period of about eight hundred years twenty-four eruptions have been recorded, and Kraabla on the northern coast, which is in a state of constant activity. On the island of Jan Meyen is a volcano which appears to be very active. This volcano is the nearest to the arctic pole (75° N. lat).

The Atlantic Proper volcanic region comprehends three groups of islands placed between the old and new continents, but at a less distance from the former than from the latter They are the Azores, the Canaries, and the Cape Verde Islands All these islands exhibit, almost without exception, unequivocal signs of their having been raised from the bottom of the sea by volcanic agency. The Azores, which, as before stated, are very frequently subject to irregular volcanic eruptions, have some semi extinct volcanoes, but only one active volcano, the peak of the island of Pico, which, however, does not appear to be very active. The Canaries have also only one active volcano, the Peak of Teneriffe, which during four centuries has only experienced three eruptions. The islands of Palma and of Lancerote have

experienced irregular volcanic eruptions. In the group of the Cape Verde Islands is also but one active volcano, situated on the island del Fuego, which seems formerly to have been very active, but during the last century it has been nearly quiescent.

The West Indian region consists of the Lesser Antilles, which lie between Grenada on the south and St. Eustache on the north, namely Grenada, St Vincent, Sta. Lucie, Martinique, Dominica, Guadaloupe, Montserrat, Nevis, St Kitts, and St Eustache. The first and the last-named of these islands appear to be extinct volcanoes, having craters, but not evincing any degree of activity On the other semi-extinct volcanoes or soufrières are found, and on Dominica, several. Active volcanoes, however, occur on the islands of St Vincent, Guadaloupe, and St. Kitts, there were eruptions in that of St Vincent in 1812 in that of Guadaloupe in 1797, and in that of St. Kitts in 1692.

58 The volcanic region of Central Asia lies in the range of the Thian-shan mountains in Chinese Turkistan, contiguous to the western portion of the province of Kansu, between 42° and 45° N lat, and between 83° and 92° E. long. It is nearly 1500 miles distant from the Indian Ocean, and 1800 miles from the Arctic Sea. The Hoang-hai or Yellow Sea is more than 1200 miles distant. Between it and the Caspian Sea is a space about 1400 miles in length. As the region in which it is situated has never been visited by European travellers its existence was not known until it was found in some passages of the writings of the Chinese historians. They describe, in a manner that cannot be mistaken, that vapours and smoke rise from their craters, and that one of them, the Pe-shan, poured streams of lava over the adjacent country, which ran to a distance of ten lis, or about four miles from its base. As far as the few passages go which have been collected from these historians, we learn that at the extremities of the region are two active volcanoes the Pe-shan, or White Mountain, on the west, and the Ho-tsheou, or Fire Mountain, on the east. It is not stated that the last-mentioned volcano has ejected lava, but it is said that the vapours rise

[illegible] theory was that of Sir Humphry Davy. [illegible] of the metallic bases of [illegible] and alkalis [illegible] the extraordinary appetency for oxygen of several [illegible] bases (potassium and sodium) induced that great [illegible] philosopher to apply it to the greatest phenomenon of nature. He supposed that the bodies alluded [illegible] found in great quantities at no great distance [illegible] the surface of the earth. When water gets access [illegible] them, it is instantly decomposed and its oxygen absorbed. This process is attended by an immediate and [illegible] remarkable evolution of heat and light, while the [illegible] are changed into earths and alkalis. Violent com[illegible] and great heat follow; the oxides which are [illegible] melt together and constitute lava; while [illegible] hydrogen and some of the water undecomposed go [illegible] to form new combinations with sulphur, chlorine, car[illegible] acid, &c., which are liberated from previous states [illegible] the heat and the various chemical agencies set in [illegible]. The power which raises the lava and throws [illegible] the ashes and scoria is the undecomposed and con[illegible] steam. Sir Humphry himself, however, after[illegible] abandoned this theory, and it has been rejected [illegible] philosophers on reasons derived from the well-[illegible] laws of natural philosophy.

[illegible] most generally accepted opinion at present is, [illegible] the volcanoes originate in the same cause from [illegible] earthquakes spring; in an immense mass of fire [illegible] occupies the centre of our globe. This sup[illegible] rests on the two facts, that everywhere on the [illegible] the matter composing the earth's crust [illegible] temperature in proportion as we descend deeper [illegible] surface; and that even those springs and wells [illegible] the sources are at a great depth, have a higher [illegible] than those which are collected near the surface of the earth.